THE ENGINEER

MARCH 26, 1954

Institution of Mechanical Engineers

THE annual general meeting of the Institution of Mechanical Engineers was held in London last Friday evening. Extracts from the council's annual report, which was presented at the meeting, are printed on page 465 of this issue. Dr. R. W. Bailey, F.R.S., was inducted to the office of president, in succession to Mr. A. Roebuck, and the following elections were announced : vice-presidents, Mr. P. L. Jones and Mr. T. A. Crowe ; new members of council, Mr. Norman Elce, Mr. J. H. Pitchford, Mr. Maurice Platt, and Mr. E. G. Sterland (Associate Member). At the meeting it was stated that this year's James Clayton prizes were to be awarded to Dr. T. W. F. Brown and Dr. A. T. Bowden. These prizes are awarded to a member, associate member, graduate or student who, in the opinion of the council, has contributed most in the year to modern mechanical engineering science by way of research, invention or experimental work.

H.M. Survey Ship "Vidal"

H.M.S. "VIDAL," which will visit the Thames at the end of this month and be inspected by the First Lord of the Admiralty and other members of the Board of Admiralty, is the latest addition to the surveying fleet. Other units of the fleet have been converted into survey ships but H.M.S. "Vidal" is the first of a new design and has been specially designed by the Admiralty to embody the requirements of the Hydrographer of the Royal Navy for hydrographic surveying and chart production. The ship has a length of 315ft and a beam of 40ft and, apart from carrying three surveying boats equipped with echo-sounding apparatus, includes in her superstructure a hangar for housing a helicopter and a deck designed for the flying-off and flying-on of the machine, which will be used for air survey photography and provide transport for parties to shore observation stations. The latest electronic aids will enable a continuous and automatic trace of the sea bed to be received and the equipment includes a large process camera and lithographic printing press to enable the results of surveys to be reproduced on board. To make the cabins, crew's living quarters, offices and working spaces as comfortable as possible in all climates from the Equator to the Poles the ship is fitted with a special air conditioning plant which operates on the reversible heat pump principle and is capable of heating or cooling the ship. J. and E. Hall, Ltd., has supplied the air conditioning machinery and Thermotank, Ltd., the air treatment plant. When cooling the air supply the refrigerating machine circulates cold water through the coils, in the air treatment units, over which the incoming air is passed and when acting as a heater the refrigerating machine reduces the temperature of the sea-water passing through it, and the heat extracted heats the water in the coils of the air treatment units. It is estimated that the method adopted saves 100kW in the electrical load. The ship is powered by twelve cylinder Admiralty standard "Range I" diesel engines driving through two twin-engine oil-operated reverse reduction, main propulsion gears supplied by Modern Wheel Drive, Ltd., and the electrical power is provided by 360kW diesel-driven generators.

Deptford Creek Bridge, Greenwich

A ROLLING lift bridge across Deptford Creek, Greenwich, was opened by the Minister of Transport and Civil Aviation, Mr. Lennox Boyd, last Monday. The bridge replaces a war-damaged structure and has, in fact, been completed for some months. It is of double-leaf, rolling-lift steel construction and is designed to carry a total load of approximately 550 tons. Each leaf consists of a front arm comprising three main girders, cross girders and decking, spanning over the Creek, and a rear arm of similar construction seated on quadrant girders on which the bridge rolls in raising and lowering. The machinery chambers and ballast boxes are located below the level of the roadway between the rear arms of each leaf, which descend into pits in the abutments when the bridge is raised. The clear span over the Creek is 70ft and the length of the front arms is 39ft to the centre of roll, the overall length of the main girders of each leaf being 61ft 3in. The radius of the quadrants is 11ft and the length of travel 12ft 6in. The bridge is 70ft wide between parapets and carries two 20ft carriageways, a 5ft central reservation and two 12ft 6in footways. The total weight of each leaf is 482 tons, including 161 tons of counterweight in the ballast box. The bridge is balanced about the centre of each quadrant except for a preponderance of 1 ton at the nose. The bridge is operated by two 35 h.p. a.c. electric motors (400V, three-phase, 50 c/s) on each leaf, operating through a differential unit and driving two trains of gearing terminating in the main pinions which move along fixed racks carried on trestles on the abutments. The east leaf is provided with two 5 h.p. motors to drive down both leaves through the last few feet of travel. Operation is through a master controller in the control cabin on the east abutment and all operations are interlocked. The bridge can be raised and lowered by one main motor on each leaf, in calm weather in three minutes, and with both motors on each leaf working it can be raised and lowered in three and a half minutes against a wind pressure of 15 lb per square foot (equivalent to a 70 m.p.h. gale). The brakes are designed to hold each leaf against a 30 lb square foot wind pressure (the equivalent of a 100 m.p.h. gale). Auxiliary hand gear is also provided for use in case of a power failure. The bridge was constructed under the direction of the chief engineer of the London County Council, Mr. J. Rawlinson. The main contractor was Cleveland Bridge and Engineering Company, Ltd., subcontractors for the machinery, control gear and electrical installations being, respectively, Sir Wm. Arrol and Co., Ltd., Igranic Electric Company, Ltd., and W. J. Furze and Co. (London), Ltd.

Institute of Refrigeration Dinner

OVER 400 members and guests attended the fifty-fourth anniversary dinner of the Institute of Refrigeration, which was held at the Savoy Hotel, London, on Wednesday, March 17th, with the president, Sir Charles G. Darwin, in the chair. Following the toasts to the Queen and the Royal Family, the Right Honourable Viscount Waverley proposed "The Institute of Refrigeration" and remarked that, although the impact of all technical developments on our lives was not wholly beneficent, most were agreed that refrigeration did come into that category. The value of keeping food cool had been appreciated from the early days, and he recalled the old ice houses which preserved ice brought from the Arctic. In the London docks, he continued, the first plant was installed in 1892, with a capacity of 706,000 cubic feet, which had now expanded to 20,000,000 cubic feet, while the total capacity throughout the country had reached a figure of 59,000,000 cubic feet. He recalled a visit to the low-temperature station at Cambridge, and while being doubtful about the dehydration of food, he was sure of the value of low temperature in the preparation of blood plasma and gamma globulin. Sir Charles Darwin, in his reply, had something to say about his recent visit to Thailand, on behalf of U.N.E.S.C.O., to investigate the state of science in that country. He briefly referred to the work of the research committee during the year, to the development of the National College for Heating, Ventilating, Refrigeration and Fan Engineering, and called the attention of the members to the International Congress on Refrigeration, to be held in Paris in 1955. Sir Rupert de la Bere, in proposing the toast of "Science and Industry," was apprehensive of science becoming the master of the world in the near future, and wondered about the effects on industry and employment. In his reply, Sir John Cockcroft supported the development of science and commented that only one-third of industry was making effective use of science, and that there was a great shortage of technicians and technologists.

Chemical Engineering in the Food Industry

A CONFERENCE on chemical engineering methods in the food industry at the Wellcome Research Institution in London was opened last week by Sir Ben Lockspeiser, the secretary of the Department of Scientific and Industrial Research. In his address Sir Ben said that the scientific study of food was a modern growth and had provided the foundation for chemical engineering in the service of the food industry, one of the many branches of chemical technology. He pointed out that chemical technology was reared in the United States as a result of the rapid growth of the oil industry. In America chemical technology, in the favourable environment of a vigorous industry that was conscious of the power of science and engineering from the beginning, progressed rapidly from batch to continuous production, through a series of bold innovations leading to self-working processes based on a high degree of instrumentation and automatic control. This progress had been of great value in creating an army of chemical engineers skilled in designing and making equipment for chemical processes of all kinds, including those concerned with processing, storage and packing of foods. Food technology, said Sir Ben, was a subject in its own right, and like other advanced technologies of the present day must be treated as such if practical results were to be obtained.

Liverpool Steam Ship Owners' Association

AT the annual meeting of the Liverpool Steam Ship Owners' Association, held on Tuesday of last week, Mr. Colin C. Black, the retiring chairman, generally reviewed the state of the shipping industry. In the course of his remarks he commented upon the value of the statistics given in the association's annual report and then referred to the limitations placed upon shipping by the lack of freedom in international finance, which restricted the flow of goods and lowered the standard of living. Politics or unorthodox economics, he continued, should not upset the outlook of the shipping industry, which must meet increasing competition energetically. Mr. Black welcomed the removal of controls by the Government, which encouraged enterprise, and he felt sure that initial difficulties would disappear in the course of time. With reference to the relationship between taxation and tonnage replacement, he called attention to the fact that, whereas British shipping was barely maintaining its position, foreign shipping was increasing in capacity and competitive strength. Such a state of affairs, Mr. Black felt, should influence the Government to give some help, especially when the size of shipping's contribution to the country's invisible exports was considered, the latest figure available being £221 million in 1952 and being equivalent to half the total for that year. The danger of the merchant fleet becoming a wasting asset, he asserted, was very real, since taxes continued to be levied on profits before provision for fleet replacements had been made.

Recording Signals from Resistance Strain Gauges

By D. A. SENIOR, M.A., A.M.I.E.E.*

(*Continued from page* 413, *March* 19*th*)

No. II—OPERATION OF WIRE RESISTANCE STRAIN GAUGES AT HIGH POWER DISSIPATION

It was shown in last week's article that static and low-frequency dynamic signals from resistance strain gauges could be recorded directly by means of a suitably designed galvanometer without intermediate amplification provided that high powers could be dissipated by the strain gauges. Commercially available strain gauges made by Tinsley, Ltd. (type "6K," 100 ohm), and Teddington Industrial Equipment, Ltd. (type "SE/A/5," 200 ohm), have therefore been tested and have been found to operate satisfactorily at much higher dissipations than have commonly been the practice. It has been found that mounted on ¼in steel sheet, the gauges show no sign of mechanical breakdown at power dissipations as high as 1W. With suitably arranged compensating gauges the zero drifts are acceptable. A composite gauge manufactured specially by Teddington Industrial Equipment, Ltd., and consisting of four 800 ohm gauges in parallel has proved satisfactory at powers up to 4W. These power ratings are such that the recording of dynamic strains by means of galvanometers is a practical proposition without recourse to amplifiers.

LAST week we described a method of designing a moving coil galvanometer to work directly with a resistance strain gauge bridge. The aim was to obtain the maximum strain sensitivity and frequency range without the use of amplifiers, and it was shown that useful sensitivities were possible for dynamic as well as static strains ; a prototype galvanometer was described which recorded static strains with an accuracy of ±0·13 ton per square inch (in steel) for static and ±0·3 ton per square inch for dynamic strains up to a frequency of 65 c/s. This galvanometer was designed to work with strain gauges dissipating 4W. Although the power dissipation required will be reduced considerably when "bobbinless" galvanometer coils are produced, the technique still demands that the gauges be run at much higher dissipations than is common practice. This part describes tests which have shown that these high power dissipations do not lead to slipping of the gauge or drifting of the balance point of the bridge.

The tests were carried out entirely on gauges of the wire resistance type. More recently, printed strain gauges† have come on to the market which have proved able to dissipate even more power than the wire wound type or alternatively the same power with a smaller gauge. The limit in multi-channel working is generally set, however, by the requirement for stabilised power. For example, operation of twelve channels at 4W per gauge requires 192W. Therefore the main advantage of the printed gauge in direct recording seems likely to be that the technique can be used on smaller structures provided the heating of the structure is acceptable.

Tests on the printed gauges have not been so extensive as those on wire gauges described here, but there is little doubt that whatever has proved possible with the wire gauges will be possible with the printed gauges, that the principles of high wattage working discovered in the tests on wire gauges will still apply, and that the same drift compensation techniques will apply equally to both kinds of gauge.

The limit to heat dissipation is set either by loss of gauge factor or by drift during the recording period. Loss of gauge factor occurs when the temperature of the gauge is such that mechanical properties of the bonding material are affected. The strain in the specimen is then transmitted imperfectly to the wires of the gauge, and the gauge becomes useless. Drift during the recording period is more complicated in origin. Provided that suitable precautions are taken in fixing and drying the gauges, the drift is almost entirely due to failure of the dummy gauge to compensate for temperature changes in the resistance of the active gauge. This may be due to differences in the temperature coefficient of resistance of the wire used in the active and dummy gauges or to difference in their thermal constants. For example, the gauge may be mounted on a ¼in steel bulkhead and the dummy upon a ¼in steel slip immersed in a waterproofing material such as "Di-gel"‡ and stuck to the plate by means of "Di-gel." Thermal capacities and impedances of the two will then differ considerably and differences will occur both in the equilibrium temperatures of the gauges and in the time constants with which these are attained. The differences appear as "drift" until the gauges "settle down." In addition, secondary stresses may be set up in the structure to which the gauge is attached by virtue of the heat generated in the gauge itself.

Once the gauge and dummy have settled down, further drift is caused only by changes in ambient temperature or failure of the gauge or dummy due to slipping. Temperature changes are compensated imperfectly if the wire composing the gauge differs in temperature coefficient of resistance from that composing the dummy whilst differences in thermal capacity and thermal impedance introduce a "settling down" period after any change in ambient temperature.

Further resistance changes in the gauge and dummy may be caused by factors not yet discussed. These are : (*a*) incomplete drying of the matrix and adhesive ; (*b*) humidity ; (*c*) internal readjustment of gauge structure, and (*d*) breakdown of insulation resistance between gauge and structure. These all produce effects of their own and, moreover, with the exception of (*d*) non-reversible effects when current is passed through the gauge. Their effect is apparent because on cooling after use the resistance of the gauge does not return to its original value. It is possible, however, by drying out under heat to render the effects of (*a*) and (*b*) negligible. The effects of (*c*) are important only when very high accuracies are required. The effects of (*d*) even at high temperatures are usually negligible ; as the temperature is increased, the gauge fails mechanically before reduction of insulation resistance is significant.

Tests which will now be described show that in practice resistance variations can be accounted for on the basis of (1) drift due to incomplete compensation by the dummy gauge for temperature effects and (2) loss of gauge factor due to temperature rise and failure of the matrix or bonding material.

The tests have been devised to show the drift which may be expected during the warming-up period and the working limit to heat dissipation as shown by loss of gauge factor and thus intolerable drift under strain.

Experimental Arrangements

Drift and breakdown tests were carried out by means of the Wheatstone bridge shown in Fig. 4. Some difficulty was encountered in finding a resistance sufficiently constant to act as ratio arms *A* and *B* ; large vitreous resistors and standard wire wound resistance boxes exhibited unacceptable thermal drift. Eventually eight 1000 ohm cracked carbon, high stability 2W resistors were arranged in pairs, four pairs being connected in series to give a resistance of 2000 ohms in each arm. The ratio arms were immersed in oil and run

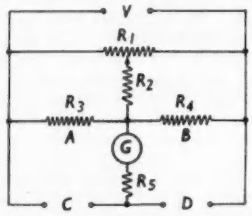

Fig. 4—Wheatstone Bridge Circuit

long enough to settle down before connecting the gauges, in the bridge. The strain gauges were connected in the arms *C* and *D*, either a pair of gauges being used or one gauge and a standard.

The standard was constructed specially and enabled the drift of one gauge alone to be determined. It consisted of twenty-five strain gauges mounted on a brass vessel filled with oil. The gauges were arranged in series-parallel to give a resistance equal to that of one gauge but with a heat dissipation per gauge of one twenty-fifth of that of the gauge under tests. Under these conditions it was assumed that there was no chance of slip in the gauges which formed the standard even at the higher power dissipations. The use of the standard was, of course, restricted to tests on the type of gauge used in its construction—the Tinsley "6K" gauge. In order to maintain high insulation resistance between the gauges and the vessel, the standard was placed in a bell jar, the air within the jar being kept dry by means of silica gel.

The balancing potentiometer R_1 in Fig. 4 was 100,000 ohms wire wound, its associated resistance R_2 being high stability cracked carbon. A Cambridge Instrument Company 50 ohm moving coil galvanometer was used, series and parallel Sullivan resistance boxes being arranged to give appropriate sensitivity and damping. Solder connections were used in all bridge arms and in the balancing circuit. Screw-down terminals or solder connections were used in the galvanometer circuit. Gauges were all mounted with "Durofix"§ cement and were not put on

* Admiralty Research Laboratory, Teddington.

† Developed by Saunders Roe, Ltd., and Technograph, Ltd. See *Aircraft Engineering*, Vol. 24, November, 1952, and *Instrument Practice*, Vol. 7, No. 10, August, 1953.

‡ Manufactured by Astor, Boisslier and Lawrence, Ltd., London.

§ Manufactured by The Rawlplug Company, Ltd., London.

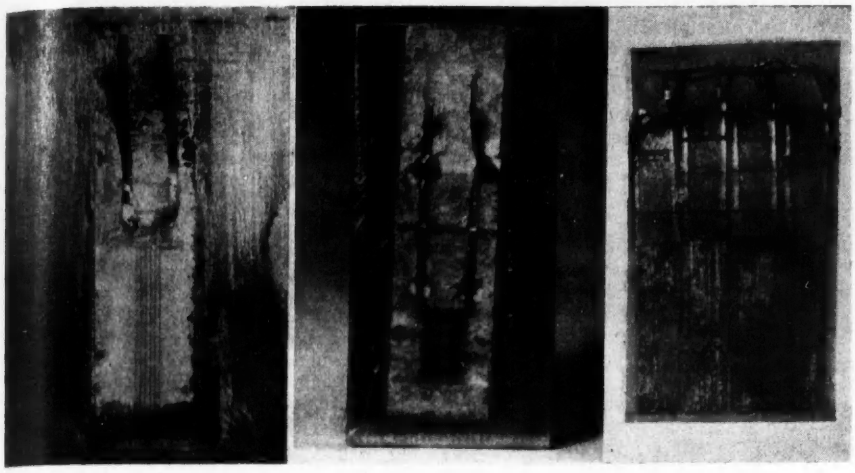

Fig. 5—(a) Tinsley "6K" Gauge (b)—Teddington "SE/A/5" Gauge (c)—Teddington Composite Gauge

test after mounting until their resistance had reached 70–100 megohms.

Tinsley "6K," Teddington "SE/A/5" and a specially constructed composite gauge were tested. The Tinsley "6K" gauge consists of a flat grid of 0·001in diameter "Advance" resistance wire occupying an area of 0·066 square inch. The gauge resistance is 100 ohms. The Teddington "SE/A/5" gauge is of the flattened spiral type and consists of sixteen turns of 0·001in diameter "Eureka" resistance wire. The winding covers an area of 0·0375 square inch. The gauge resistance is 200 ohms. The Composite gauge was specially constructed to have a higher heat dissipation than the "SE/A/5" gauge but to be of the same resistance. It consists of four 800 ohm gauges mounted on the same paper and connected in parallel by external "busbars." The total winding area is 0·6 square inch, sixteen times that of the "SE/A/5."

Photographs of the three gauges are shown in Fig. 5. As an indication of size the winding area of the composite gauge is 1in square. The protecting layers of paper have been removed to expose the filaments.

Breakdown Tests

For this purpose the gauges under test were mounted on a sheet of mild steel 24in by 6in by ¼in, the steel being flexed to produce a stress at the position of the gauge of 5 tons per square inch. The gauges were covered with cotton wool to ensure that heat dissipation occurred only through the metal, a condition which obtains in practice when the gauges are waterproofed (with "Di-gel" for example).

The bridge was completed with the ratio arms described above and a fourth arm which depended on the gauge under test. With Tinsley gauges the standard already described was used. With the Teddington "SE/A/5" gauges another "SE/A/5" gauge was used, this gauge not being strained. With the Composite gauges, two were mounted on opposite sides of the same sheet of steel. The busbars on each gauge were cut leaving the individual 800 ohm gauges connected in parallel pairs. These were connected to form a four-gauge bridge, the electrical arrangements being such that the maximum resistance change occurred in bending the steel sheet.

In each case, the voltage applied across the bridge was increased step by step and the movement of the galvanometer—the zero drift—noted, a long settling down period being allowed at each voltage before proceeding to the next. In this way the limit of heat dissipation by the gauge as shown by loss of zero stability was determined. Slip of the gauge (failure of the bond between wires and matrix) also leads to loss of gauge factor and non-linearity and hysteresis in the strain/resistance calibration but this is insufficiently accurate as a practical method of determining the onset of slip. An indication of temperature changes in the gauge was obtained by arranging a mercury thermometer with the bulb under the cotton wool lagging near the gauge.

Typical results are shown in Fig. 6. The gauge resistance increases initially as the gauge "warms up" but falls when slip occurs at about 1·5W. The drift is expressed as a percentage of Full Scale Deflection, this being equivalent to a stress of 5 tons per square inch in steel (a strain of one part in 2900 and a resistance change of twice this amount). Slipping begins in the Tinsley "6K" gauges at 1·5W to 2W dissipation, in the Teddington "SE/A/5" gauges at 2W to 3W and in the Composite gauges at around 8W or 10W. These suggest that the Tinsley "6K" gauges may be run safely at 1W dissipation, the "SE/A/5" gauges at 1W to 1·5W and the Composite gauges at 4W, under the conditions of the test, i.e. with gauges mounted on fairly large ¼in steel plates and ambient temperatures around 20 deg. Cent.

Drift Tests

Drift tests were carried out at "safe" wattages with the gauges unstrained (except by the residual setting stresses which are caused by shrinkage of the matrix on drying). Temperatures were again measured with the aim of finding the cause of zero drift at those wattages, which are, of course, considerably higher than those usually regarded as satisfactory.

The bridge arrangement shown in Fig. 4 was used, the arms *C* and *D* being occupied by two gauges stuck back to back on a sheet of steel which was unstrained. Tinsley "6K," Teddington "SE/A/5" and Teddington Composite gauges were all tested. Results typical of the "SE/A/5" gauges are shown in Fig. 7. In some cases the test was repeated with the ratio arms reversed. In this way records were obtained in which the temperature coefficient of the ratio arms (*a*) assisted and (*b*) opposed that of the gauges.

Many tests were made at various wattages and these showed clearly that drift could be accounted for qualitatively on a basis of temperature changes. Rapid temperature changes were associated with rapid drift and the additive and subtractive effect of temperature coefficients was evident when the ratio arms were reversed. Temperature coefficients of resistance of the three types of gauge and of the ratio arms were measured but it was found that the temperature changes as measured were insufficient to account for the whole of the drift. The explanation is probably that neither the oil temperature of the ratio arms nor the temperature as measured beneath the lagging over the gauge was as high during the test as that of the component in question and that the tempera-

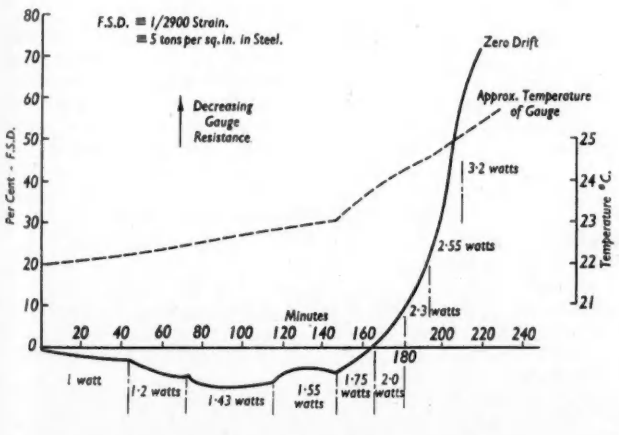

Fig. 6—Breakdown Test on Tinsley "6K" Gauge

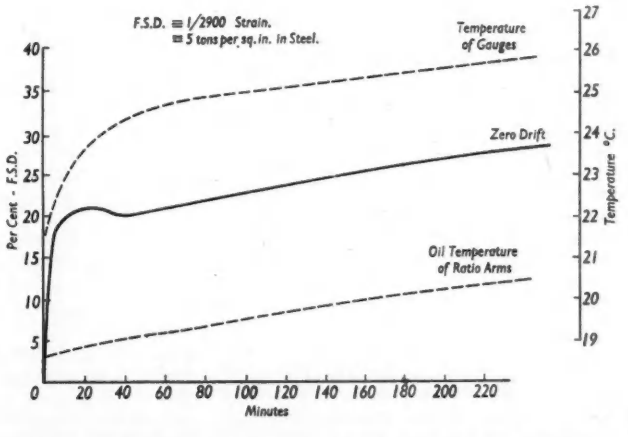

Fig. 7—Drift Test on Teddington "SE/A/5" Gauges at 1·0W per Gauge

ture measured could be regarded only as a guide to the changes which occurred.

Temperature Compensation by Means of Dummy Gauge

The experiments which have been described show that the " 6K " and " SE/A/5 " gauges at dissipations up to 1W and the Composite gauges up to 4W exhibit very little zero drift after the initial " settling down " period—only a few per cent of full-scale deflection (5 tons per square inch in steel) per hour.

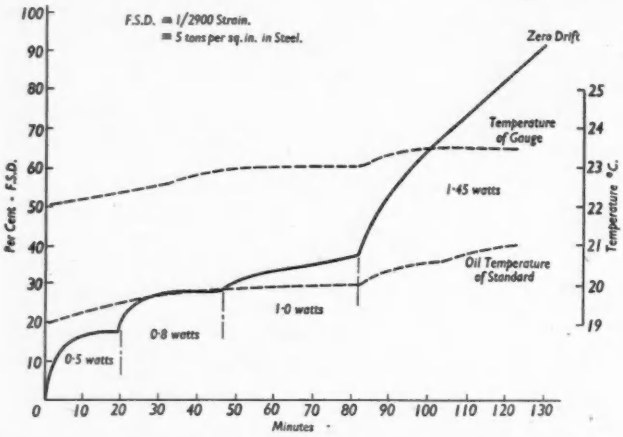

Fig. 8—Breakdown Test on Tinsley " 6K " Gauge on Dummy Slip in " Di-Gel "

Such drift as occurs seems almost solely due to differences in temperature and temperature coefficient of resistance.

Inadequate temperature compensation by the dummy gauge will thus be the main source of drift in practice. The problem is more serious when the gauges are run at high dissipations as self-heating occurs especially in the dummy. This is generally mounted on a small slip of metal and so tends to reach a higher temperature than does the active gauge which is fixed to a larger structure. This leads to increased drift during the settling down period and, if serious over-heating occurs, may lead to relief of setting stresses in the dummy.

The dummy slip must therefore be designed so that temperature variations in the structure due to changes of ambient temperature are followed rapidly by the dummy and heat generated in the dummy gauge is readily conducted away. Both conditions are met by arranging the dummy slip in good thermal contact with the structure under test. The first also requires the thermal capacity of the dummy slip to be as small as possible.

The limit is set by the transmission of stress to the dummy slip through the material between it and the structure especially if the structure is stressed by bending. It is common practice to cover the active gauge with some water-proofing material such as " Di-gel " and insert the dummy slip in a mound of " Di-gel " close by. Experiments confirmed that in neither case did slip or relief of setting stresses occur at the wattages recommended provided that the thickness of the " Di-gel " layer between dummy slip and structure did not exceed $\frac{1}{16}$in. A typical test with a Tinsley " 6K " gauge on a dummy slip in " Di-gel " is shown in Fig. 8.

There is no doubt, however, that the dummy gauge under these conditions is nearer to the breakdown temperature than is the active gauge. It is worth while, therefore, to reduce still further the thermal impedance between dummy slip and plate. A reduction of the time lag in compensation for changes in the ambient temperature also results since the thermal time constant of the dummy system is thereby reduced. At the same time a reduction in the stress transmitted to the dummy slip is called for. Even with a dummy slip as thick as $\frac{1}{8}$in a 1 per cent stress transmission occurred with the Tinsley " 6K " gauges when the " Di-gel " layer was $\frac{1}{16}$in thick. With the Composite gauges which require a larger dummy slip, the " Di-gel " layer had to be increased to $^1/_{10}$in when the dummy gauge overheated. By reducing the " Di-gel " layer between dummy slip and structure to $\frac{1}{32}$in the chance of over-heating was made negligible but stress transmission precluded this method unless the strain in the structure was induced by direct tension or compression with no bending.

Various bonding materials other than " Di-gel " were tried in an attempt to achieve adequate heat transmission with negligible stress transmission but none was found. The necessary performance was finally obtained by machining away 0·010in from the underside of the dummy slip except at the ends where a $\frac{1}{8}$in wide strip across the width of the slip was left to form a bridge. The gap was filled with oil. Calculations showed that this clearance would be suitable for all but the thinnest structural plating (which in any case would be unable to conduct away the heat from the gauges) stressed in bending to 5 tons per square inch and that the frictional forces between the ends of the slip and the plating brought about by the surface tension of the oil film would be insufficient to transmit appreciable strain.

To sum up, the compensating gauge should be mounted on a $\frac{1}{8}$in thick slip of the same metal as that of the structure under test. The area of the slip should be as small as is practicable. If the structure is stressed with little or no bending the slip may be inserted in a mound of " Di-gel " with a layer $\frac{1}{32}$in thick between it and the plate. If bending is present a 0·010in gap should be machined from most of the under-side of the dummy slip, the gap filled with oil and the whole covered with " Di-gel."

Tests with Compensating Pairs of Gauges

Pairs of gauges were tested at various wattages, one being mounted on a 24in by 6in by $\frac{1}{4}$in steel sheet stressed to 5 tons per square inch in bending and the other mounted on a $\frac{1}{8}$in thick dummy slip. Failure (excessive drift) always occurred at a rather lower wattage than that in the corresponding breakdown test in which the gauge was mounted on a large sheet of steel. The safe wattages already quoted are still applicable, however, provided that the dummy slip is correctly designed.

Insulation Resistance

Zero drift has proved, within the safe dissipations already determined, to be bound up closely with temperature changes. Temperature changes affect the dimensions of the gauge and the resistivity of the wire and this yields a temperature coefficient of resistance which depends on the wire material and on the material on which the gauge is mounted. In addition, since the gauges run at relatively high temperatures there is the possibility that resistance changes will arise from leakage of current between the gauge and the structure.

It was found that on application of a d.c. potential between gauge and structure, the leakage current diminished from its initial value, becoming steady after about 10 minutes. The resistance between gauge and plate, calculated from the steady values, is shown in Fig. 9 for a Composite gauge mounted on a large sheet of $\frac{1}{4}$in mild steel. The gauge was covered with " Di-gel " as it would be in practice, and run at various wattages. The gauge was heated by 50 cycles a.c. so as to avoid so far as possible interference with the d.c. measuring circuit. Some interference is inevitable since the resistance/voltage curve is not linear and the flow of a.c. through the wires superposes an alternating voltage on the applied direct one of magnitude which varied with distance along the wire of the gauge.

The curve shows that there is a considerable drop in leakage resistance between gauge and plate at the proposed dissipation of 4W, the leakage resistance being about 40 megohms when the gauge is mounted directly on the plate. A similar test showed that the leakage resistance was 20 megohms when the dummy slip arrangement was used.

It may be shown (see Appendix) that when the potential of the plate is midway between those of the ends of the gauge wire, the effect of leakage resistance r on a gauge of resistance R is to reduce the apparent resistance of the gauge in the proportion $1 : (1-R/12r)$. Thus a 20 megohm leak in a 200 ohm gauge causes a drift of $8 \cdot 10^{-7}$ or 0·1 per cent of Full Scale Deflection (5 tons per square inch). The effect of leakage at the recommended wattages is therefore negligible.

The effect of leakage resistance when the structure is not midway in potential between

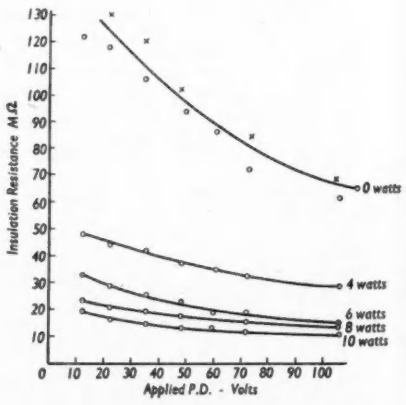

Fig. 9—Insulation Resistance of Teddington Composite Gauge Mounted on $\frac{1}{4}$in Steel Plate

the ends of the gauge is discussed in the Appendix, and it is shown that if the potential across the bridge is V and there is a potential difference of V_0 between one end of the battery and the structure, then the current I_G flowing through the galvanometer on account of a leakage resistance r_1 in one of the gauges connected to that end of the battery is given by the equation :—

$$I_G = \frac{R}{4r_1(R+G)}\left[V_0 - \frac{V}{3}\right]$$

where R is the resistance of one arm of the bridge, all the arms of which are assumed equal, and G the resistance of the galvanometer.

Thus, if the structure is maintained at a potential such that $V_0 = V/3$, the effect of leakage will be theoretically zero. In practice this would require that the active

and dummy gauge be arranged so that their common point is connected to the battery and not the galvanometer as is usual. The dummy slip and structure could then be at the same potential. The arrangement is shown in Fig. 10.

Conclusions

(1) When mounted on ¼in steel plate and the plate stressed at 5 tons per square inch, "Durofix" bonded strain gauges retain their gauge factor and exhibit very little zero drift at heat dissipations up to the following values :—

Tinsley "6K"	1W
Teddington "SE/A/5"	1W
Teddington Composite	4W

These figures apply to ambient temperatures around 20 deg. Cent.

Such zero drift as occurs is closely related to temperature changes.

(2) The breakdown wattages under the same conditions are :—

Tinsley "6K"	1·75–2W
Teddington "SE/A/5"	2–2·5W
Teddington Composite	8–10W

(3) Compensating gauges mounted on ⅛in steel slip give satisfactory operation at the recommended wattages provided that good thermal contact is provided between the dummy slip and the structure. This may

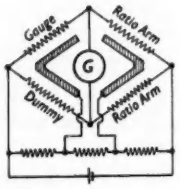

Fig. 10—Bridge Circuit in which Effects of Leakage are Eliminated

be arranged with the Tinsley "6K" and Teddington "SE/A/5" gauges by pressing down the dummy slip on a thin layer of "Di-gel." With the Composite gauges this procedure results in transmission of stress to the dummy gauge if much bending occurs in the structure. This difficulty may be overcome by the use of a suitable machined dummy slip and an oil film between the dummy slip and the structure.

(4) At the recommended wattages the heat generated is such that a drop occurs in the insulation resistance between the gauge and the material to which it is bonded. This drop is insufficient to cause appreciable zero drift but should it be more serious with bonding materials more satisfactory mechanically, the effect could probably be much reduced by means of a slight modification in the bridge circuit.

(5) These power dissipations are such that the recording of dynamic strains by means of galvanometers is a practical proposition without recourse to amplifiers. They mean for example that the galvanometer described in Part I will give useful accuracy over its frequency range of 0 to 65 c/s.

APPENDIX

Zero Drift Produced by Leakage Between Gauges and Structure

In the mounted gauge, the wires are considerably nearer to the structure than to each other. Leakage from one part of the filament to another through the matrix may thus be ignored in comparison with the leakage to and from the structure. The gauge may thus be regarded as a transmission line with leakage to earth, as shown in Fig. 11.

Then it may be shown[2] that if V_0 is the potential difference between one end of the gauge and the structure, and i_0 is the current flowing in at that end, the potential drop along the gauge beginning at that end :—

$$E=V_0\left\{1-\cosh\sqrt{\frac{R}{R_L}}\right\}+i_0\sqrt{R\,.\,R_L}\,.\,\sinh\sqrt{\frac{R}{R_L}} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where R and R_L are the gauge and leakage resistances respectively.

The current leaking into the structure :—

$$i_L=i_0\left\{1-\cosh\sqrt{\frac{R}{R_L}}\right\}+\frac{V_0}{\sqrt{R\,.\,R_L}}\,.\,\sinh\sqrt{\frac{R}{R_L}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

If $V_0=E/2$, i.e. the potential of the structure is midway between those of the ends

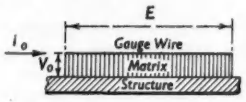

Fig. 11—The Strain Gauge

of the gauge, then the apparent gauge resistance,

$$R^1=2\sqrt{R\,.\,R_L}\,.\,\tanh\tfrac{1}{2}\sqrt{\frac{R}{R_L}} \quad . \quad . \quad (3)$$

or, approximately, when the leakage resistance is high,

$$R^1=R\left[1-\frac{R}{12R_L}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The condition $V_0=E/2$ does not necessarily obtain in practice. It is true if there is no return path from the structure to the gauge ; then the leakage current is zero and the condition that $V_0=E/2$ follows. In a bridge in which two or more strain gauges are involved other leakage paths must be considered.

Now the leakage between the gauge and structure may be replaced (by J. L. la Cour's theorem) by resistances between the ends of the gauge and the structure of magnitude

$$\frac{\sqrt{R\,.\,R_L}\,.\,\sinh\sqrt{\frac{R}{R_L}}}{\left[\cosh\sqrt{\frac{R}{R_L}}\,.\,-1\right]}$$

and a resistance in series with the gauge of magnitude

$$R\left[\sqrt{\frac{R_L}{R}}\sinh\sqrt{\frac{R}{R_L}}\,.\,-1\right].$$

So long as R_L is large compared with R these resistances are very nearly equal to $2R_L$ at each end of the gauge and $R^2/6R_L$ in series with the gauge, as in Fig. 12.

Consider the case of a bridge with four equal arms of resistance R, the leakage resistances being r_1, r_2, r_3 and r_4.

The procedure in deriving the zero drift

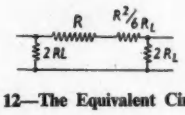

Fig. 12—The Equivalent Circuit

(i.e. the current flowing in the galvanometer under these conditions) will be to assume that the structure is at a potential V_0 relative to one end of the battery the potential across which is V. Each gauge will be considered separately and its contribution to the out of balance evaluated. Since the out of balance is small, the effects are linear and may be added together.

The bridge is shown in Fig. 13, the equivalent leakage resistances for one gauge being included. Consider the contribution to the galvanometer current made by the two resistances $2r_1$. The resistance across the

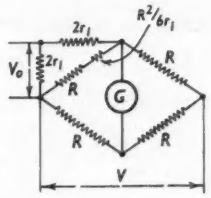

Fig. 13—Bridge with One Gauge Leaking to a Structure at Potential V_0

P.D. V_0 makes no contribution ; the contribution of the other resistance varies linearly with V_0 and V. When $V_0=0$ or V the galvanometer current is then :—

$$\text{Plus or minus}\ \frac{V\,.\,\frac{R}{2r_1}}{4(R+G)}$$

G being the resistance of the galvanometer. It follows from the linear relationship mentioned that the galvanometer current is :—

$$\frac{(2V_0-V)R}{8r_1(R+G)}\,.$$

The contribution made by the resistance $R^2/6r_1$ is dependent only on V to a first approximation and is

$$\frac{V\,.\,\frac{R}{6r_1}}{4(R+G)}\,.$$

Thus the total current is :—

$$\frac{R}{r_1(R+G)}\left\{\frac{2V_0-V}{8}+\frac{V}{24}\right\}$$

$$=\frac{R}{4r_1(R+G)}\left\{V_0-\frac{V}{3}\right\} \quad . \quad . \quad . \quad . \quad (5)$$

The zero drift when all the gauges leak may be obtained by summing the effects of the individual gauges under the appropriate conditions. If $V_0=V/3$ the effect of leakage is reduced to zero.

References

[1] C. R. Urwin and K. H. Swainger. *Proc. Roy. Ae. Soc.*, November, 1947.
[2] E. Jones and K. R. Maslen, *Research and Memoranda* 2661, H.M. Stationery Office.

(To be concluded)

Ganga Bridge Project

The Ganga bridge project has now reached a stage when tenders are being invited for the construction of a rail-cum-road bridge across the Ganga River at Mokameh, in Bihar. Two tentative designs have been prepared for the proposed bridge, which is likely to be the biggest of its kind since the end of the war. Design No. 1 consists of nine main spans, of which seven will be 600ft each, two 500ft each, and four shore spans, 104ft 8in each, centre to centre of bearings. The main spans will be balanced cantilever spans with a 100ft cantilever arm at each end and 400ft suspended spans. The second design consists of fourteen main spans, each 413ft 4in centre to centre of bearings, simply supported at the ends. The mile-long bridge will be supported on piers, foundations for which will have to be taken down to a depth of 170ft below the low-water level. The roadway decking will be in reinforced concrete. The project, estimated to cost about Rs. 15 crores (about £12,000,000) will be executed, under the authority of the Central Government, who have appointed a general manager, who is also the chief engineer of the project. This departure from the conventional mode of execution was recommended by the Commission, which went in great detail into the economics of the project and advised a semi-autonomous executive authority on the lines of Damodar Valley Corporation.

French Locomotive Experiences

By EDWARD H. LIVESAY

No. III—DIESEL-ELECTRIC "AUTORAIL" AND COAL TRAINS, PARIS AND LENS

(*Continued from page* 414, *March 19th*)

THE engine rostered for the run from Lens to Paris was No. 150-P3, a 2–10–0 four-cylinder compound (Figs. 19 and 20) designed by Monsieur de Caso ; the chief details are given here :

Cylinders (outside), h.p.	19·6in by 25·6in
Cylinders (inside), l.p.	27·5in by 28in
Wheels truck	Diameter 3ft. 2½in, lateral play ½in
Wheels, driving	Diameter 5ft 2in, lateral play ¼in, fifth axle
Boiler, diameter	5ft 6¼in
Boiler, length	13ft
Steam pressure	265 lb
Heating surface :	
Large tubes	664 sq ft
Plain tubes	205 sq ft
Serve tubes	972 sq ft
Superheater	633 sq ft
Firebox	243 sq ft
Total	2717 sq ft
Grate, length	11ft 6in
Grate, width	3ft 3in
Grate, area	37 sq ft
Tractive effort (compound)	59,525 lb theoretical
Factor of adhesion	3·33

Fittings

Westinghouse brake (compound pump) ; Lemaitre blast pipe ; Walschaerts valve gear, piston valves ; one Nicholson thermic siphon ; "Standard" H.T.1 stoker ; A.C.F.I. feed water heater ; electric light ; Flaman recorder. Maximum speed permitted, 65 m.p.h.

Entering the cab, I found it to be clean ; somewhat unexpected this, as dirty coal makes cleanliness next to impossible on most French engines. Not only the cab, but the whole engine, was immaculate ; this one was not setting off from its home shed with a heap of cinders and soot in front of the smokebox door, as I saw a British express engine do not so very long ago from a London terminus, at the head of a famous train. Mechanical stoking, which I was glad to see employed, would no doubt play a part in keeping the footplate decent, and electric light was there, not only in the cab, but under the running board, and in the headlamps ; of course, there was a Flaman recorder. There were five persons on the footplate : Monsieur Leseigneur at the regulator, Monsieur Fillon in attendance as interpreter and courier, Mecanicien Gerard standing by, Chauffeur Gryselier and myself, yet there seemed to be no crowding, as the cab, though short, was wide, and there was plenty of room on the tender footplate. The train consisted of sixty-seven, four-wheel, 30-ton (gross), air-braked, screw-coupled trucks, and weighed approximately 2000 tons. A few of the trucks were not actually air-braked, but they had the train pipe in position to bridge the gaps and ensure continuity. The night, fine and warm, was black as a pocket, the train getting away at 2.35 a.m., moving off very gently out of consideration for the screw couplings, which, I should imagine, is not the best conceivable gear for use with heavy loads. High-pressure steam was used in all four cylinders, but immediately after the getaway compound working began, with the regulator full open and maximum valve travel for both sets. There was no slipping—I do not know why, as the factor of adhesion is only 3·33, but a "pusher" engine at the rear must have had something to do with it. This is employed on coal trains starting from Lens to help up the long climb over Vimy Ridge, the gradient beginning almost in the yard, and has been the practice for a couple of years, a recent pit subsidence having further complicated things. No. 150-P3 was evidently going "all out" up the 4-mile bank, the cut-offs being still the maximum, 47 per cent h.p. and 58 per cent l.p., the respective steam chest pressures being roughly 240 lb and 51 lb—boiler pressure is 265 lb. A slight knock was audible on the left side, said to be axleboxes ; the engine had run 60,000 miles since last shopping, and was to do an additional 10,000 before hoisting.

Nearing the crest of Vimy Ridge the pusher dropped off and the engine passed the summit at Bailleul going solo, the l.p. cylinder pressure reading 63 lb—the h.p. figures in my notebook are unreadable—probably they equalled boiler pressure. The l.p. cylinders are inside, 27½in diameter, which means that their centre lines must be over 28in apart, and it would be interesting to have the dimensions of the big end and axle journals, but I cannot supply them. Was there not once "much argument about it and about" on the impossibility of building four-cylinder compound express engines in Britain because there was insufficient room between the frames for large l.p. cylinders ? They seem to be able to manage it in France ! To continue : at the top of the bank the speed had fallen to 8 m.p.h. ; fifteen to twenty scoops of coal were fed to the front of the grate, which is long and narrow and not very steeply inclined, the steam gauge needle having shown a slight tendency to recede. The rake was used and then slid straight back into its receptacle on the tender in the practical French manner. Why turn it end for end and risk putting somebody's eye out, British fashion ?

Once over the peak, running free down the other side of the ridge, the speed rose to 45 m.p.h., to which it is limited for track reasons. Arras was passed at 3.15, practically on time—Lens had been left 5 min late. It was pleasant in that well-lit cab, every gauge being easily readable from my vantage point on the tender ; they seemed more legible even than is usually the case by daylight. The lamps were kept full on, dazzle evidently

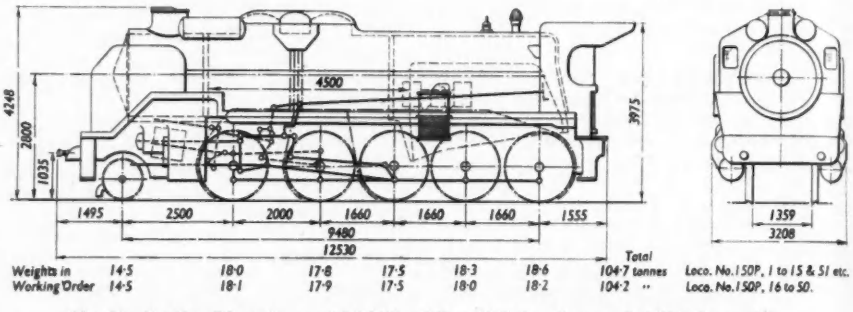

Fig. 20—Leading Dimensions and Weights of Four-Cylinder Compound 2-10-0 Locomotive

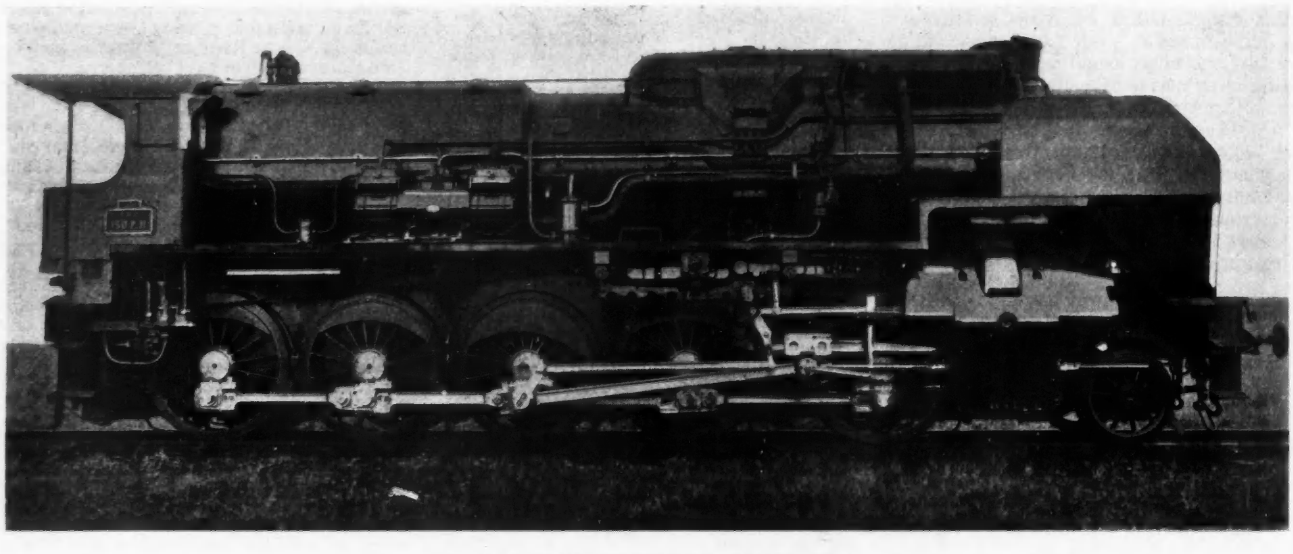

Fig. 19—Four-Cylinder Compound 2-10-0 Locomotive

being considered no embarrassment in view of the vividly bright signal lights. Acetylene lamps were on hand for emergencies ; in Britain oil lamps are provided for all purposes ; are any " spares " supplied at all ? Perhaps they are considered unnecessary, the light from oil lamps being anyway so poor that if one does go out nobody would be likely to miss it. The stock excuse, that we cannot afford such luxuries as electric light on locomotives is invalid ; it was not employed even when we could afford it. Inquiring, I was told that if the electric system fails the train stops at the next station

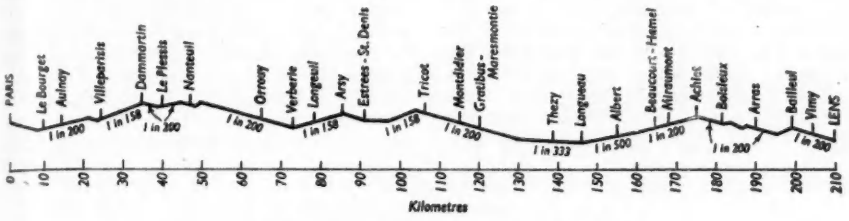

Fig. 21—Profile Between Lens and Paris

to pick up a large lamp—type not ascertained —or hand lamps are put in position at the front end.

For half an hour or so the engine had been pulling steadily up the long incline from Arras to the Achiet summit ; the exhaust, typical of a compound, was pleasant to listen to—full, yet soft, telling of steam expanded to the limit and passed out through a five-jet Lemaitre blast pipe without pulling the fire to pieces. The blowdown was opened ; this is done every 40km and costs 55 gallons ; again a few scoops of coal were hand fed into the fire-box, which incidentally had one thermic siphon ; the pressure gauge quickly responded. The top of the bank was passed at 3.45 a.m., the speed rising to over 40 on the 1 in 200 drop down the other side to Miraumont. The riding at this speed was good, and my notes witness to it—anyone could read them (most of them, anyway). The degree of legibility of notes made on the footplate is an excellent oscillation meter, almost as good as an Hallade recorder. One engine on which I travelled in France rode so abominably that I was forced to give up note-taking altogether ; the log would have been unreadable, even though entered standing ; most of my attention was needed to avoid being thrown out of the cab. It is scarcely necessary to say that this was not a French engine, nor to explain where it came from, which will be done in a subsequent article. A locomotive nightmare, *that* engine !

By this time conditions in the cab had become what I like to feel at an early stage in a long run. We had all shaken down and were getting used to each other ; I had " slung my hammock," as they say in the Navy, which means much the same thing ; everything was going well ; the first heavy part of the route lay behind, and as the profile (Fig. 21) shows, it had been fairly severe. Perhaps there was another reason, too, for optimism—the small hours of the night were past, when vitality is at low ebb ; one sensed that dawn could not be far away. Was there not already a certain greyness over there to the left, where before there had been only the all-pervading blackness ? Thirty miles had been covered, and respect for engine and crew was becoming firmly established.

It is acknowledged that the French are an ingenious and practical people, and this often shows on their locomotives ; in No. 150-P3's cab there was an example of it. The water gauge had a scale alongside, showing where the level in the glass would be on varying gradients up or down, mid-position indicating level track—predicating, of course, a fireman up to his job, who keeps the boiler content what it should be. Ingenious, is it not ? After admiring this gadget for some time it dawned on me it could be used in lieu of the gradient profile left behind at Asnieres. One drawback was that it did not anticipate things—you only knew what the engine was doing when it was doing it, and it was impossible to tell how long the job would last ! Somewhat like skating on thin ice—you don't know how thin it is until you go through.

Albert went by at 4.10 a.m., roughly 34 miles in 95 min, quite a good performance with 2000 tons taken over a by no means easy route. Dawn was well under way now ; the cab lamps were switched off, and one began to notice little things that had hitherto gone unrecorded despite electric lighting. The coal was of the same uniform, well-screened grade that had been used on the " Hudson " 232-U1 ; evidently this is the rule on French stoker-fired engines—the conveyor is only called upon to convey, not crush as well. It certainly seemed to give very even firing, Gryselier having little difficulty in keeping the pressure where it should be, well up. On the other, Leseigneur's, side of the footplate the reverse gear came out of night's semi-obscurity, revealing two scales, h.p. and l.p., and showing that the two sets of valve gear could be varied separately or simultaneously ; further, by means of a combining arrangement, one wheel served for all manipulation, no matter what method of working was being employed.

A lengthy stop was scheduled for Longueau, where the engine was to receive ground attention, such as the cleaning of grate, ashpan, smokebox and so on ; and for breakfast, which was becoming a cheerful prospect. The train came to a stand at 4.43 a.m., the 60-odd miles from Lens having been covered non-stop in 128 min. The interval in the big yard was pleasant, full of locomotive and social interest. Considerable ash and cinder had accumulated in the smokebox, masking several of the lower rows of tubes, one or two of which were leaking ; the reader is reminded the engine had done 60,000 miles since shopping. These things having been attended to, and a truck with defective running gear cut out of the train, some photography was indulged in, one result being Fig. 22, after which we adjourned to the yard master's office for breakfast, where Leseigneur demonstrated he could handle a frying pan as well as a regulator. The enginemen, good fellows, did not accompany us ; I had already discovered that equality and fraternity, to say nothing of liberty, though in theory the very warp and woof of Gallic social relations, in practice did not seem to extend much beyond the confines of the cab. For example, when the Chief of Traction becomes chef and cooks breakfast, the enginemen are not invited to share the repast—they eat on the engine ! Noticing this, and on subsequent occasions other faint but suggestive signs that equality of social status was not always necessarily accepted as a law of the Medes and Persians in France, later I approached another official, asking him to expound unto me the Scriptures of this little problem, and was quite surprised at the emphasis with which he did so. " Familiarity with the enginemen ! Ah, yes, Monsieur Livesay—in the cab ! At other times, certainly not—they keep their place ! " Somehow I had not expected to find this sort of thing in France ; it would not work too well in Canada, I know—on occasion there I have wished it did ! Naturally, much depends on what sort of engineman one is with—there are different brands. However, I was not an official of the S.N.C.F., so my attitude of camaraderie toward these good companions could be, and was, different ; it did not always stop short at the cab. Fortunately, I am not as snobbish as once upon a time, having lived a long while outside my native land ! Besides, all the enginemen I met in France were so kind and friendly that I was perfectly willing to fry an egg for any one of them, and moreover share it with them when fried. I would not even make an exception of a mecanicien unfortunate enough to be named Stalin—he, too, would be welcome to share my egg. In my experience, very extensive by now, I have found it easier to be democratic in Canada and France than in Britain—and as a rule safer. Sad to confess, my sensitive and sympathetic soul has a tendency to shrivel somewhat, to harden, as it were, whenever I come back to my native land. Yet seldom, in any country, where enginemen are concerned !

Fig. 22—Locomotive 150-P3 at Longueau. Left to Right, Mecanicien Gerard. M. Leseigneur, the Author and Chauffeur Gryselier

Looking round the engine at Longueau, several interesting features were noted. From the picture (Fig. 19) the lightness of the motion will be evident. There is not a pound of superfluous weight in the side rods ; in fact, the first and fourth sections of coupling rod look positively slender, yet this was a powerful engine designed for heavy work, which it does with perfect success. The valve gear shows the same care in reducing weight to the minimum. The A.C.F.I. feed water heater seen on this engine is a standard fitting on nearly all French locomotives, and it is strange that though it has been tried on British engines it has never been

seriously adopted. Evidently in France the fuel economy which it achieves is considered well worth the cost of installation and maintenance—two flatly contradictory opinions here. Mechanical lubrication is employed all over the engine wherever possible; the Westinghouse brake, universal in France, is probably essential there in view of the length and weight of the trains, particularly freight, which are often, as in this case, 2000 tons or more, run at fairly high speeds. What a transport tragedy it is that small, unbraked, loose-coupled trucks are still trundling about Britain in this year of grace 1954, halving track capacity and bringing in their train a variety of annoyances and positive dangers unknown in France, where air-braked goods trains are universal. It was a pleasure to travel on this long coal train and notice the fine control exercised over it under all conditions by virtue of a Westinghouse compound pump. In stressing this, I am not forgetting the major difficulty militating against the adoption of continuous braking on British goods and mineral trains—a million and a half trucks unfitted, a large proportion being in private hands, making conversion a tremendous problem. The fact, however, that British railways are now State-owned should make a solution of the difficulty more feasible; surely it must be tackled some day, the day being long overdue. I have travelled in the cab of an engine hauling a long British coal train—a Beyer-Garratt running between Cricklewood and Toton—and well do I remember the tender care that had to be exercised in controlling it, its slow speed, and so forth; the contrast in almost every respect between it and this French counterpart was very striking; the latter fast and easily handled, the former—but let's forget it!

The restart from Longueau was made at 5.30 a.m.; at 5.50, passing Thezy, "up rose the sonne, and up rose Emilie" as the train, having left the main line to Paris, began running along the route through Montdidier and Orrouy to Le Bourget, where the journey was to end. It was lovely country here, very different from the grimy coal mining district round Lens, the long train snaking its length round curves, over streams, past farms and little towns, from which a faint haze of smoke was beginning to rise as breakfast fires were lit in preparation for another day. There were wooded hills and winding roads here, too, and the level rays of the newly-risen sun began to warm the chilly morning air, which smelt very fresh and sweet. It was all very pleasant, and one of the most interesting, unusual runs made during the whole tour. The country hereabouts reminded me of the Forest of Dean, the parallel being underlined on noticing alongside the railway what might have been originally a Roman road—a narrow, roughly stone-paved lane, kerbed, crossing a little stream by an ancient single-arch bridge, and leading, as also did the railway, through a little hamlet named Gratibus-Maresmontie—there is quite a Roman tang about that! I thought of its counterpart, that fascinating second century track which can be followed for miles through the woods between Lydney and Gloucester, one I never fail to wander along when visiting the neighbourhood, from which I have prised a flat stone that will be built into my house in Victoria, B.C. This country south-east of Longueau somehow seemed to link the past with the present; it was easy to imagine Cæsar's legions marching through it, and when an inquiry as to the meaning of numbers—60, 75, &c.—boldly displayed on boards beside the track, brought the explanation that they indicated the number of trucks sidings would hold, the link was strengthened—they probably stemmed directly from the day when the Romans got into traffic difficulties with their elephant transport on that self-same narrow causeway. But I am running into trouble myself—on consideration it was Hannibal, not Cæsar, who used elephants to haul trucks, and he did it in the Alps.

We ran through Montdidier at 6.24; the engine was working very sweetly, and had done so from the start. There were no knocks, clangs or leaking glands, only that slight thump on the left side. Climbing the long and heavy gradient to Tricot, much being 1 in 250, the regulator was full open, h.p. cut-off 47 per cent, l.p. 58 per cent, resulting in steam chest pressures of 18 hpz. and 4 hpz. respectively. If the gauges were accurate, these figures proved there was nothing wrong at the front end, boiler pressure and h.p. steam chest pressure being about equal. These figures were jotted down when the engine was going "all out," with speed down to 8 m.p.h. on a gradient of 1 in 166. My notes read, "Just about all she can do!" As if to mark the wisdom of touching wood, I had scarcely scribbled the words in my notebook when a rhythmic hiss began to sound on the right side of the engine, and a corresponding wisp of steam blew from the piston-rod packing of the h.p. cylinder. The train topped this heavy gradient at 6·53 m.p.h., with the speed so low approaching the summit that the possibility of stalling occurred to me—and perhaps to Leseigneur and Fillon also, everyone being silent, and a trifle *distraite*. The notebook brings the incident back to me clearly: "If could think of this noble engine stalling might do so now—dropped nearly to walking speed." But the ignominy was spared us—the top was passed, everyone relaxed and smiled again, and I returned to my eyrie on top of the tender, from which I could look right over the cab roof and watch everything that went on, inside and outside the cab. A fine vantage point with the wind on either bow, but less satisfactory when it was dead ahead, in line with the chimney. The cab was really quite convenient for an observer; though short, it was wide, and the circulation area was ample if the tender footplate be included in it. It was easy to keep out of the way of people, and thanks to the mechanical stoker it kept fairly clean—for a French engine, that is!

Another long and even steeper climb, some of it 1 in 143, began near Verberie, rising through Orrouy-Glaignes, and continued for several miles through Nanteuil-de-Haudouin to Le Plessis; again the speed fell to 8 m.p.h., but the engine pulled sturdily up the gradient, despite the leaking gland hissing viciously on being asked to hold back 265 lb of steam. Over another peak, at Dommartin, with the regulator eased and cut-off shortened, the leakage ceased, so evidently the condition was not serious—the gland merely wanted tightening. The running was faster now, over 40 m.p.h., down several miles of 1 in 200, to Villeparisis; we were within measurable distance of Le Bourget and beginning to think of lunch, and the end of this enjoyable experience, unlike any other I had ever made. Cab conditions, free from the stress and strain more or less inseparable from passenger work and high speed, made it very pleasant; one could move about, chat and change position without getting in anyone's way, even Gryselier's, the stoker-engine, carrying on its tireless work with little attention from him, the A.C.F.I. feed pump also being automatic and equally persevering with boiler supply. Things would have been different if he had been busy with his shovel, and between times fussing with an injector; in that case, this observer would have kept religiously clear, to avoid making a nuisance of himself. I was told that approximately 12,000 lb of coal would be burnt during the run, which works out at about 88 lb per mile, quite a reasonable amount for a 2000-ton train taken over a fairly heavy road.

Running out of the hilly, park-like country with its small farms and winding roads, the landscape became Manitoba-like; straight, poplar-lined roads, large wheat fields, vistas of stooks and golden stubble over which the sun poured down—it had sulkily hidden itself an hour or so from Longueau. The train kept up a steady 40 m.p.h. over this section, until Aulny-sur-Bois was reached and passed, slowing, at 9.14, one minute early. We were in the suburbs of Paris now, and Le Bourget Airport came into view on the right; slowing still, the great yard was entered, the train coming to a stand at 9.17 a.m., having covered the 130 miles from Lens in 6 h 42 min, inclusive of a 47 min stop at Longueau, which makes the running average 22 m.p.h.

The run had been most interesting and successful, the little defects in the engine that had showed up being in no way serious—incidentally, they were the only faults that developed while running on any engine ridden during the whole of my experiences in France. A gland springing a leak under high pressure, a couple of flues doing ditto—that was all. The axle knock mentioned had been in evidence before the run began, and would not call for attention before another 10,000 miles were covered, in addition to the 60,000 already done. Apart from these trivialities, the engine had run like a sewing machine, in which it merely followed the rule worked to by every locomotive on which I rode in France. Finally, everybody on the engine, from Monsieur Leseigneur, down through Inspecteur Fillon, Mecanicien Gerard to Chauffeur Gryselier—who comes last only because somebody must—had been kindness itself, doing everything possible to make the trip informative and enjoyable—and had succeeded. But in this, too, they had only followed the French rule.

There followed lunch at a nearby café—good food, well served, in clean, bright surroundings. I thought of the average British restaurant in a similar environment, and a feeling of sadness stole over me. Why, oh why, must our gastronomic facilities average so dingy, drab and fly-blown? Soap is plentiful enough in Britain—more so than in France, as a matter of fact. The will to use it must be weak. I will say nothing about good taste; possibly we are not really civilised yet, as I suggested to my companions, amid laughing protests. I reminded them of 1066 and all that, advocating another invasion, but a peaceful one this time, to teach us how to cook, run restaurants—and build locomotives! We have much to learn in all these directions, and on this note of good fellowship the sitting ended, the trio proceeding by train to the Gare du Nord and "La Maison Blanche," where *au revoir* was said to Monsieur Leseigneur, who was going to the Pyrénées next day on holiday. He must try not to worry, but we shall meet again.

(To be continued)

PORTABLE AIR COMPRESSORS.—It is announced by the Consolidated Pneumatic Tool Company, Ltd., that a new portable air compressor it has introduced is fitted with a Rolls-Royce oil engine. The rated capacity of this machine is 315 cubic feet per minute, at a maximum working pressure of 125 lb per square inch. The power unit is the Rolls-Royce "C6NFL" six-cylinder oil engine of 93 b.h.p. at 1250 r.p.m. (twelve-hour rating).

High-Tensile Steel Bolts for Structural Joints

(By Our American Correspondent)

No. II—(*Concluded from page 417, March 19th*)

In the last few years, the use of high-tensile steel bolts for structural joints in place of rivets has found a number of interesting applications in the United States, and the procedure involved has now been standardised with the approval of the American Research Council on Riveted and Bolted Structural Joints. This article deals with the properties of the bolts, nuts and washers employed, describes a representative fastening method and outlines a number of applications to railway bridges and other structures.

Impact Wrenches

Most of the initial uses of high-strength structural bolts in building and bridge construction have been under the requirement that the bolts be tightened with a torque spanner to a specific tightening torque. The use of torque spanners becomes rather impractical, however, as high-strength bolts gain use in large new structures or when the bolts are ⅞in and larger in diameter. The size of the torque spanner necessary for large bolts and the amount of

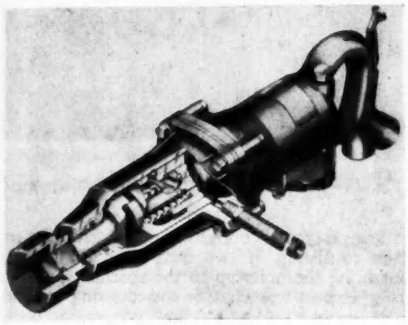

Fig. 6—Pneumatic Impact Wrench

force required to operate it make the use of this tool quite cumbersome. A commercial torque spanner for 1in bolts is over 5ft long and a force of at least 142 lb must be applied to its handle to develop the torque which has been specified for 1in bolts. These conditions made it evident that the use of power-driven impact wrenches would be necessary in any structural scheme involving a large number of bolts.

Figs. 6 and 7 are cut-away views of the " 534 " impact wrench made by the Ingersoll-Rand Company, which is representative of the air-driven tools now used in America for the tightening of high-strength bolts. It is capable of handling bolts up to 1¼in diameter and weighs only 27¼ lb. The design of the impact unit makes it possible to apply, in rapid succession, thousands of rotary impacts to a nut,

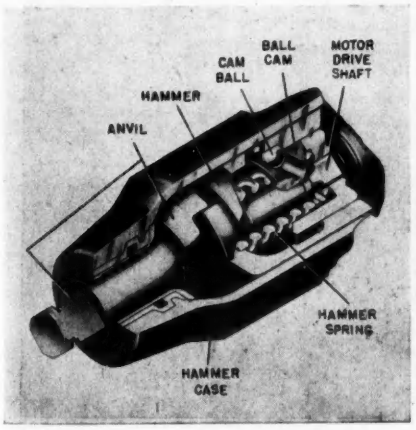

Fig. 7—Impact Unit of Pneumatic Wrench

while the motor of the tool runs at a constant and uniform speed, with little or no torque reaction or shock to the operator. When running down the nut, the jaws of the hammer and anvil are in contact, as shown ; the ball cam, hammer and anvil rotate as a unit and the impact wrench performs as any conventional torque wrench. As the nut begins to tighten and the resistance to turning becomes greater than the initial pressure of the hammer spring, the anvil remains stationary and the rotation of the ball cam causes the cam balls to roll up the cam grooves, pulling the hammer back over the ball cam and compressing the hammer spring. When the hammer is drawn back far enough, the jaws of the anvil and hammer disengage and the hammer jaws slip over the top of the anvil jaws without touching them. The power stored in the compressed hammer spring now pushes the hammer forward toward its original position with respect to the ball cam. As the cam balls reach the lower part of the cam grooves, the hammer has attained maximum velocity and the hammer jaws deliver a powerful " rotary impact " to the anvil jaws. These " rotary impacts " occur as often as 2900 times per minute.

Occasionally, compressed air may not be available at a construction site and it is necessary to use an electrically-driven impact wrench, such as the " 34 U " unit made by the Ingersoll-Rand Company and illustrated in Fig. 8. It has an impact unit similar to the one described above, is capable of handling bolts up to 1¼in diameter and weighs 32½ lb. Fig. 9 shows one of these electrically-driven wrenches being used in the field, while Fig. 10 illustrates the use of a pneumatically-driven unit.

Experience obtained with pneumatic impact wrenches suggested the possibility of using wrenches that drive to " refusal " and controlling the operating air pressure so that they will tighten the bolts to a specific tightness. The necessary control can be attained by inserting a spring-loaded diaphragm air regulator in the hose which feeds each wrench. The distance between the regulator and the wrench is not of critical importance because the effect of any change in it can be incorporated in the calibration of the wrench. This calibration of the wrench can be established by an adjustment of the regulator so that the wrench will develop the requisite bolt tightness when it is run to " refusal."

The need for a simple means of measuring the bolt tightness became evident at an early stage in erection work involving high-strength bolts. Simplicity and convenience are essential to frequent checking of the wrench operation, and calibration by the measurement of bolt tension is desirable because this tension is the essential factor in the use of high-strength bolts. One scheme developed for measuring the bolt tension attained in the process of calibrating impact wrench operation was the use of electric resistance strain gauges on a hardened steel tube through which the bolt could be placed and tightened. Objections, pointing out that the scheme would be too complex for field use, however, led to the trial of a method in which the elongation of the overall length of the bolt during tightening was measured to determine the tension in the bolt. In this method the elongation of each of the various sizes, lengths and threadings of the bolts to be used was determined by dial gauge micrometer measurements under a load equal to the desired bolt

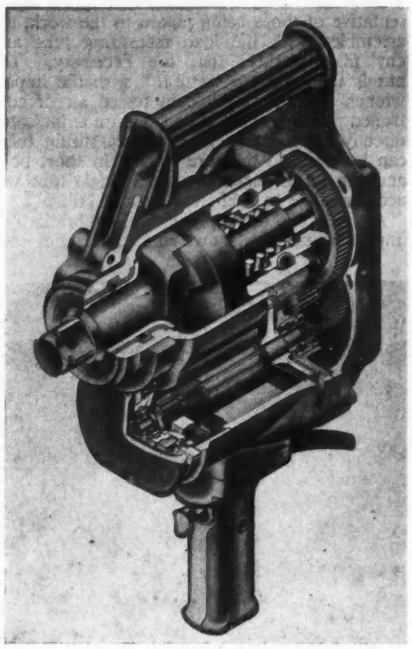

Fig. 8—Electric Impact Wrench

tension applied in a testing machine. A table of these elongations, a dial gauge micrometer and a test block were furnished to the erector. He then calibrated the impact wrench by adjusting the air regulator supplying each wrench so that the elongation of bolts tightened in a test block with the wrench run to " refusal " was the same as that tabulated for the bolt being used. The dial gauge micrometer had large radius anvils and was arranged to fit in a keyway in the testing machine grips as well as in the field test block. It was expected that this scheme would permit consistently accurate measurements to be made without machining special measuring centres in the head and point of each bolt used for calibration. A trial of the scheme, however, has shown it to be somewhat unsatisfactory, as various factors combined to create unacceptable variations in the measurement of the bolt elongation.

The use of the originally considered electric strain gauge device with an indicating meter to show bolt tension directly in pounds currently appears to be the most promising means of measuring bolt tension in the calibration of impact wrenches. It eliminates the testing machine measurement of bolt elongations and the subsequent field use of these data and it avoids the variables that are encountered in the mechanical measurement of bolt elongation. The tubular load measuring device can be calibrated in a compression testing machine and its indicating meter marked directly in pounds of axial load on the tube. In the field,

Fig. 9—Electric Impact Wrench in Operation

a bolt, nut and hardened washers, all representative of those being placed in the work, are assembled with the load measuring tube and any filler washers that are necessary. The nut is then run to "refusal" with the impact wrench operating with compressed air of controlled pressure and the bolt tension is indicated directly on the meter. Load measuring tubes can be made to measure tension in short bolts and can be arranged so that a single tube will accommodate two different sizes of bolts.

A hydraulic device for the calibration of impact wrenches is shown in Fig. 11. For each

Fig. 10—Pneumatic Impact Wrench in Operation

bolt size to be used, the air pressure and approximate time of "torqueing" required to actually stall the wrench are determined, using as many trial bolts as necessary. The calibrating device consists of a 60-ton hydraulic puller jack, and by means of the yoke arrangement shown, the tension applied to the bolt by the impact wrench is read directly on the pressure gauge. In the photograph, the bolt being tested is hidden inside the framework. The nut bears against the supporting frame and is connected to the threaded rod through the centre of the jack by means of the welded assembly which is visible between the two.

The use of a pneumatic impact wrench does, of course, entail some noise. During the short interval of time when the wrench is spinning the nut into bearing against the hardened washer, the noise from the wrench ordinarily would be masked out by the level of noise incident to other construction operations. In fact, the much sharper sound which follows when the nut has

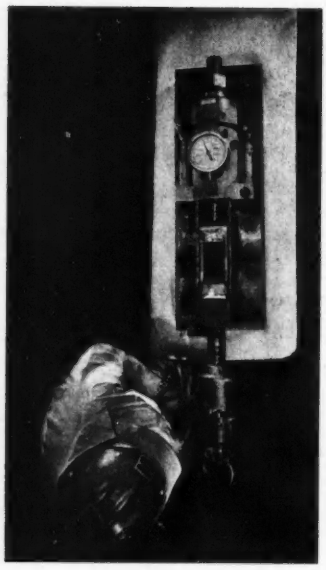

Fig. 11—Hydraulic Calibration Device

seated may also be obscured by many common "construction noises." The maximum noise level involved has been described as approximately one-half that of an ordinary riveting hammer. Its duration likewise is only half that required to drive a rivet. It is not without significance, therefore, that many of the schemes using high-strength bolts which have already been completed, or which are contemplated for construction in the immediate future, have been additions to hospitals where much study was given to this aspect of the problem.

Building Construction

Two representative building frames erected recently with the aid of high-tensile bolts are shown in Figs. 12 and 13. The former is the steelwork for a three-storey office building at Springfield, Massachusetts, and the latter is the framework for a large car assembly factory at Arlington, Texas, which required some 150,000 high-strength bolts for the primary connections. It is of interest to note that in tendering on the steelwork for the assembly works, the contractors were asked to quote alternatively on the basis of field riveting and on the use of high-strength bolts. The successful low bidder submitted the same price for both methods of field erections which confirms the experience of several American fabricators who have found little difference in the direct cost of using bolts as compared to rivets.

A large jet engine manufacturing works at Utica, Michigan, has been designed on the basis of using high-strength bolts for all primary connections. Secondary connections, such as purlins and sash angles, will make use of ordinary black bolts, as would have been the case had the principal connections been riveted. The large size of this single-storey building justified considerable planning in organising the erection forces to utilise the new bolting technique. The steelwork was erected using one pin and one fitting-up bolt in each connection, in the conventional manner. The final bolts were installed by steel workers whose task was completed when these bolts were made snug with an ordinary spanner. Since there were a great number of identical connections, each man was assigned the work of placing the bolts

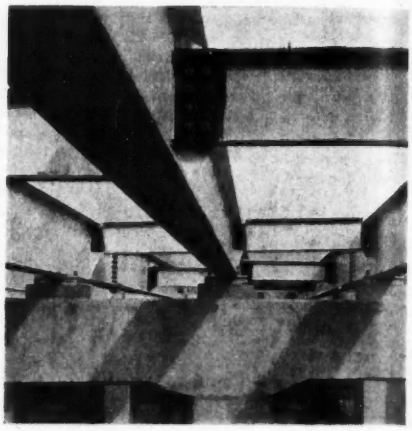

Fig. 14—Beams Showing Unpainted Bolting Areas

in a single type of connection. Tightening gangs, each consisting of two men who did nothing but bring the bolts up to the specified prestress using impact wrenches, followed along immediately behind. Most of the connections could be reached without scaffolding, and it was found that it took three to four men to keep ahead of a tightening gang. The average production per man, counting all of those engaged in the work, was approximately 150 bolts per day. Two tightening gangs, confining their activities entirely to this one operation, installed as many as 3100 bolts per working day. It was found that when several bolts were required in a single connection, the tightening of the later bolts often increased the total clamping effect on the connection to such an extent that the first bolts tightened often had to be retightened. Thus, connections having as many as seven holes in a single row could be quickly brought up to the proper tensions by tightening the centre bolt first, then proceeding from the top hole down to the bottom one, and giving

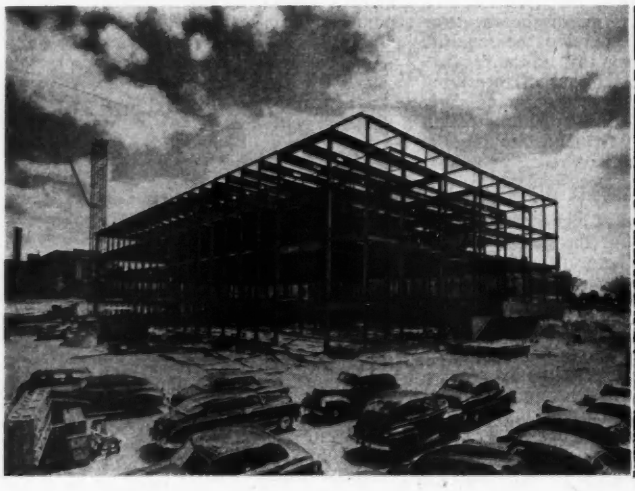

Fig. 12—Steelwork for Office Building at Springfield, Massachusetts

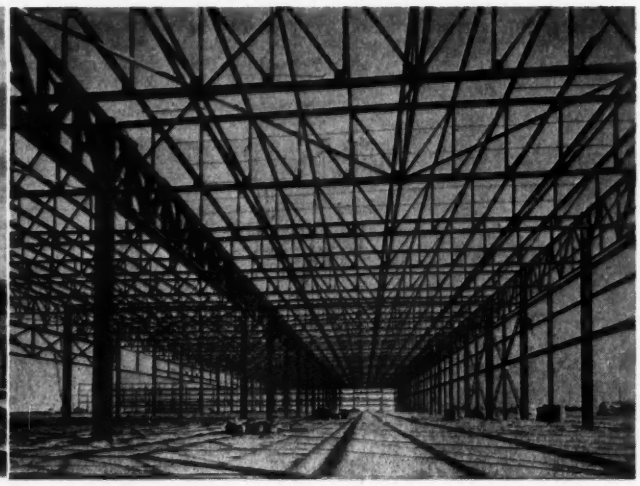

Fig. 13—Steelwork for Car Assembly Works at Arlington, Texas

the centre bolt a second treatment at a later stage.

One of the largest current contracts involving the use of high-tensile bolts is the Mayo Memorial Medical Centre at the University of Minnesota in Minneapolis. The structure comprises a seventeen-storey main building and four six-storey wings and is expected to be completed next spring. The use of riveted connections was precluded in this case on account of the proximity of other hospital buildings. Though tenders were requested on the basis of either field welding or bolting, no bids involving welding were received. While ordinary black bolts were used in the erection of the wings, all beam-to-column connections in the main building were fitted with high-strength bolts, a total of 160,200 of the latter being employed.

An item of expense involved in the use of high-strength bolts is the need to leave bolting areas unpainted until the completion of field erection, as indicated in Fig. 14. The current American specifications require that all faying surfaces be free of paint, lacquer, oil and all other materials which would interfere with the development of friction between the parts. This requirement was established because laboratory tests have indicated the possibility of a gradual slip under long-sustained loading, due, no doubt, to a shearing action within the body of the paint film. As in the case of similar provisions usually invoked where connections are to be field-welded, it is necessary to note on the shop drawings all areas where the shop paint is to be omitted. This work in the drawing office, together with additional work in the fabricating shop involved in marking limits for shop painting on the steel parts, and some expense in "touching up" the shop coat in the field after erection entails certain additional cost. In an effort to eliminate this expense, research work is now in progress aiming at a solution to the problem, by means other than the omission of shop paint.

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Electrical Engineers' Exhibition

No. II—(*Concluded from page 434, March 19th*)

THE Electrical Engineers' Exhibition organised by the Association of Electrical Engineers was held at Earls Court from March 16th to 20th; more than 180 exhibitors, consisting mainly of electrical manufacturers, took part. In the following paragraphs we conclude our review of the exhibition by describing a few of the interesting items that were on show.

Metropolitan-Vickers Electrical Company, Ltd.

Air-blast circuit breakers are being made by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17, for installation at Staythorpe, Carrington and Melksham on the 275kV Super Grid, and a model (Fig. 6) of one of these equipments was exhibited.

In these circuit breakers operation and arc extinction are carried out by compressed air at a normal pressure of 325 lb per square inch. Each phase has eight interrupter heads, arranged in two groups of four, with a double-break sequence switch between the groups. Each interrupter head encloses a single axial-flow nozzle containing a retractable moving contact. When the circuit breaker is closed, air is admitted to the interrupter head where it forces back the movable contacts against spring pressure. The arcs are extinguished by the action of the compressed air. Consecutively, air is by-passed from the blast valve to an air motor to operate the sequence switch which, when opened, cuts off the supply of air to the interrupters, allowing the spring-loaded contacts to reset. The total break time, from trip impulse to arc extinction, is 3 cycles. The breaker is closed by closing the sequence switch.

Each break is shunted by a "Metrosil" resistor having a non-linear characteristic. These shunts serve the dual purpose of grading the duty equally across the multi-break and, because of their non-linear resistance properties, of effectively damping switching surges produced by the high-speed operation of the circuit breaker. The impulse level of these circuit breakers is 1050kV.

This company is also showing one of its "VIH" vertically isolated switchboards for industrial and power station auxiliary services at 3kV to 11kV. The enclosure is of folded construction to give a clean appearance. Each circuit breaker can be raised into the service position, or lowered, by a worm-and-bevel drive operated by a detachable double-crank handle and, being mounted on a carriage, is readily removable from its cubicle. The "V1" oil switch, which is suitable for ring main and similar duties, will make and break its full-load current of 400A. It is also capable of making on to a fault of 33·4kA (peak); this is equivalent to 75MVA at 3·3kV, 150MVA at 6·6kV and 250MVA at 11kV. The switch is fitted with an earthing position and contacts, and provision is made for the insertion of cable testing plugs. Both the circuit breaker units and the oil switch are fully and positively interlocked.

"V1H" switchboards are available in breaking capacities up to 150MVA at 3·3kV and up to 250MVA at 6·6kV and 11kV, the current ratings being 400A, 800A and 1200A.

English Electric Company, Ltd.

Among the equipment shown by the English Electric Company, Ltd., Queen's House, Kingsway, London, W.C.2, was a "Superform" fuse-switchboard (Fig. 7). We learn that this exhibit earned for the company the award of the silver plaque presented (for originality, design, workmanship and ease of operation and maintenance) by the organisers of the exhibition, the Association of Supervising Electrical Engineers.

The "Superform" fuse-switchboard is built up with chassis-mounted fuse switches, each having quick-make-and-break action. When it is not in use the operating handle is retracted into the switch housing, thus allowing the spring-loaded, chromium-plated, engraved aperture cover to return to its normal flush fitting position, as can be seen from Fig. 7. The cover can be locked in the "off" position, to prevent the switch being closed when an electrician is working on the outgoing circuit.

The door of the fuse-switch compartment is hinged at the left and secured at the right-hand side by two chromium-plated thumbscrews; an interlock is provided so that the door cannot be opened while the switch is in the "on" position. Similarly, the switch cannot be closed with the door open, but provision is made to enable this interlock to be "defeated" for inspection and maintenance purposes when the supply is "off."

"On" and "off" indicators, visible through a small glass window in the door, are operated from the moving contact blade assembly. Flush-fitting meters can be accommodated to suit individual requirements, and the meter panels are hinged to provide ready access to the instrument connections and small wiring. All terminals, &c., are completely insulated and small wiring is enclosed in metallic flexible tubing between the busbar chamber and meter panel.

Both incoming and outgoing cables are in the compartment at the rear of the switches, the panels at the back of the board being removable to provide access for cabling up. When removed,

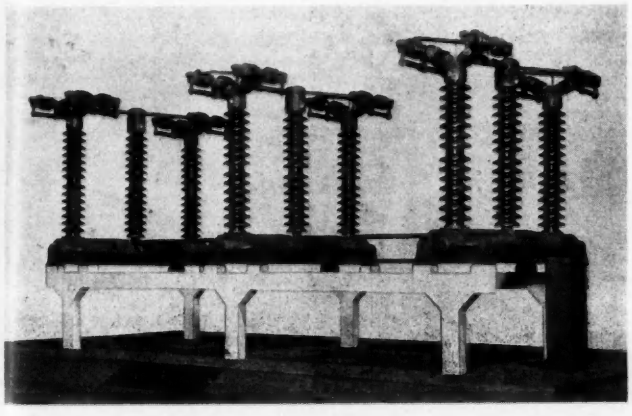


Fig. 6—Model of 275kV Air-Blast Circuit Breaker for the British Super Grid—Metropolitan-Vickers

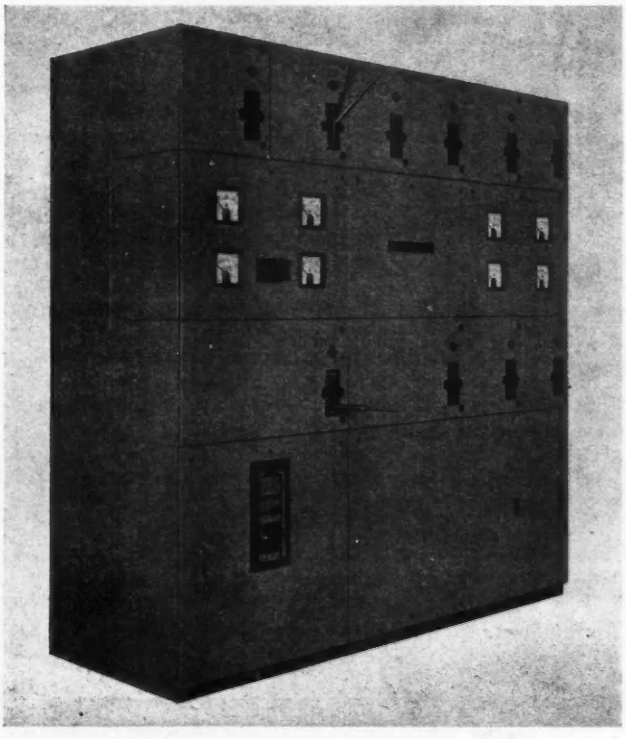


Fig. 7—"Superform" Low-Voltage Fuse Switchboard —English Electric

no live metal is exposed, as each back connection from the fuse-switches is completely insulated. Thus, spare circuits can be connected up safely with the busbars " alive " and other circuits on load.

For the protection of small wiring an h.r.c. fuse is inserted at the point of connection of potential circuits to either the busbars or the outgoing fuse-switch terminals ; this fuse is additional to the potential fuses on the instrument panel which are of smaller current rating. Thus, an instrument fault is cleared by the potential fuses on the panel as they will discriminate against the larger fuse at the point of supply. The larger rated fuses protect the small wiring.

Lancashire Dynamo Holdings, Ltd.

Seven members of the Lancashire Dynamo group of companies were represented on the stand of Lancashire Dynamo Holdings, Ltd., St. Stephens House, Victoria Embankment, London, S.W.1.

Two medium-voltage, 25MVA switchboards (one, a " Unit-to-Unit " heavy industrial board, and the other, a newly designed unit cubicle flush board), were shown by Lancashire Dynamo Switchgear, Ltd. The heavy industrial switchboard consists of standard 25MVA busbar chambers with fuse switches mounted above and below the busbars, and assembled on floor pedestals. To demonstrate the flexibility in physical layout that can be achieved with this equipment the switchboard was exhibited in the form of a right angle. A number of possible variations in circuit layout, incoming and outgoing feeders cable entries and metering facilities were to be seen.

The unit cubicle flush switchboard that was exhibited embodies a 25MVA standard busbar system with flush fitting fuse switches, and is designed for use in positions where appearance is of importance. The cubicles are bolted side by side to form a complete switchboard as shown in Fig. 8. On this particular board, the right-hand section comprises a 300A triple-pole and neutral incoming fuse-switch.

The central section of the switchboard comprises a 100A triple-pole and neutral fuse-switch above the busbar chamber and a 100A triple-pole fuse-switch below the busbar chamber, this latter switch fitted with back-up h.r.c. fuse for three-phase, direct-on starting contactor being fitted into the lower section of the cubicle. The start/stop push buttons for the contact are also fitted on the central section, together with an 0/500V meter with a selector switch to read voltages phase to phase and phase to neutral. The left-hand section comprises an eight-way, triple-pole and neutral fuse distribution board in the lower compartment, this fuse board having a 200A triple-pole and neutral fuse-switch for isolation.

Above the busbar section there are two 60A double-pole fuse-switches, the load being indicated by ammeters mounted on the hinged cover of the busbar section. All switches and busbar sections are provided with hinged covers to simplify maintenance. Alternative cable arrangements can be provided—straight entry, reverse entry, right hand or left hand.

A new example of " Varionic " variable-speed motor drive incorporating the recently developed " Nevitron " single-anode rectifier tubes was shown by Nevelin Electric Company, Ltd. The control unit exhibited consists of a self-contained cubicle about 30in by 30in by 65in high, which houses the rectifier unit with grid control and motor protective gear. It is suitable for direct connection to three-phase a.c. supplies up to 440V without a rectifier transformer and can handle drives rated up to 75 h.p., with a wide speed range.

Woods of Colchester, Ltd.

Propeller fans up to 60in diameter, contra-rotating fans and single-stage Aerofoil fans were among the exhibits shown by Woods of Colchester, Ltd.

In Fig. 9 we show two views of the new Aerofoil " Maxcess " fan, which was originally designed to meet marine requirements for maximum accessibility of the fan motor. It consists of a retractable axial fan carried on hinges in a main casing, which is flanged at each end for fixing. The retractable fan can be swung out from the main casing for servicing or inspection without disturbing the permanent fixture or electrical

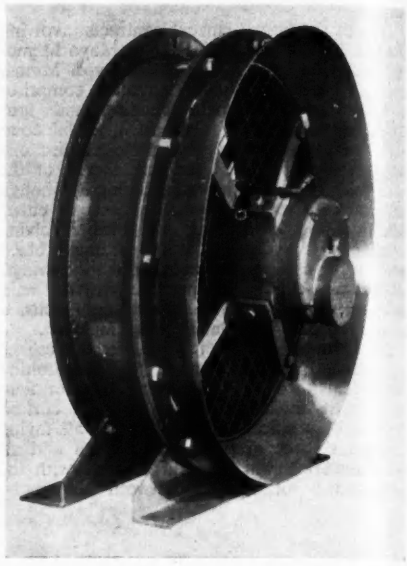


Fig. 10—Aerofoil Fan with Short Casing Covering the Impeller Only—Woods of Colchester

connections ; indeed, the fan can be kept running while it is swung out. All electrical connections are taken to an external weather-proof terminal box on the main casing. The joint between the fan and main casing is sealed top and bottom against air leakage, damp and dust by quickly detachable rubberised canvas strips carried on spring steel.

Another exhibit, the " S-type " Aerofoil fan (Fig. 10) has a very short casing covering the impeller only. Because of its compactness it is especially suitable for applications where the fan is mounted at a duct termination, but it can be equally well inserted into a run of ducting. The motor and impeller are supported on one side of the

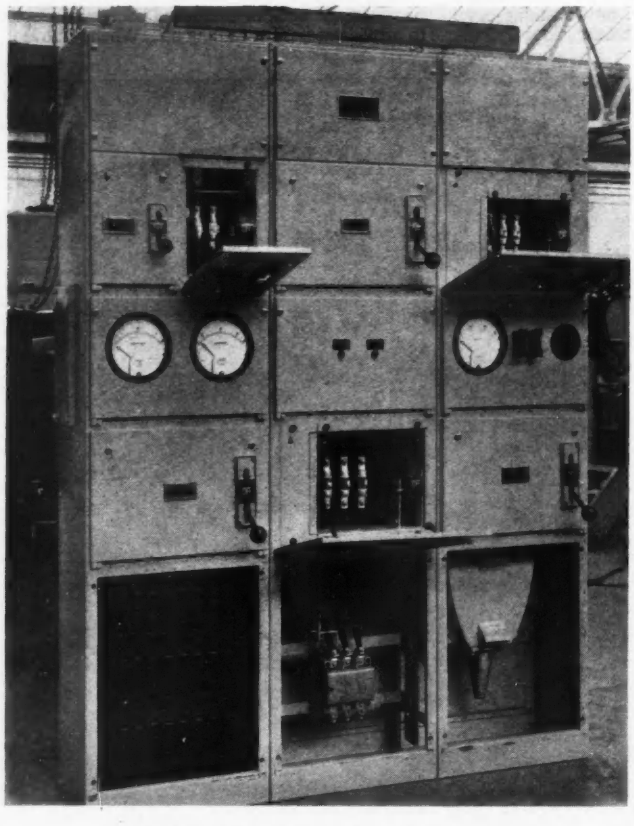


Fig. 8—Unit Flush Fitting Switchboard—Lancashire Dynamo

Fig. 9—Aerofoil " Maxcess " Marine Fan Casing—Woods of Colchester

casing by four arms. When used at the intake of a system the fan is supplied with a cone inlet.

M.T.E. Control Gear, Ltd.

A panel designed for variable-speed control of d.c. motors when the only supply available is alternating current was shown by M.T.E. Control Gear, Ltd., Leigh-on-Sea, Essex. This equipment is known as the "Vari-drive" and it is designed to rectify the a.c. supply and to provide a d.c. motor with smooth speed variation

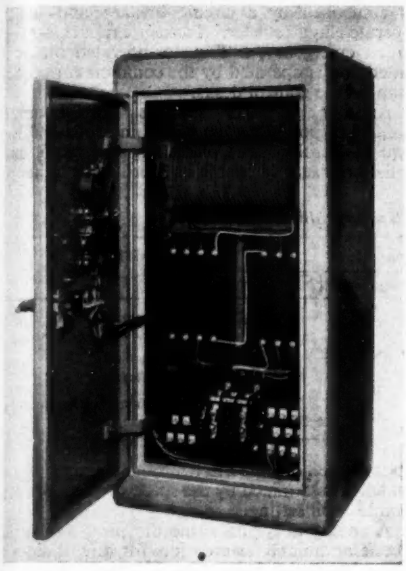


Fig. 11—"Vari-drive" Control Panel for Variable-Speed D.C. Motors—M.T.E.

over a range of 15 : 1, with constant torque characteristics.

The exhibit, which is illustrated with its hinged cover open in Fig. 11, is suitable for motors up to 3 h.p. Briefly, the control equipment consists of a transformer and an electromagnetic system based on the principle of the transductor ; the output from the transductor is fed to metal rectifiers, giving vernier speed control of the d.c. motor.

Standard Telephones and Cables, Ltd.

To illustrate, diagramatically, the principles of impulse frequency telemetering an animated wall chart was displayed by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2.

This company has developed an impulse frequency system of telemetering capable of transmitting readings of watts, VAR, volts, amperes, &c., over individual line circuits with facilities to permit a line circuit to be shared by a number of readings ; these facilities are particularly useful where it is expensive to provide multi-core circuits. A special instrument has been designed to deal with system frequency, and an electronic device which will translate a direct voltage into a corresponding impulse frequency is also available as a transmitter for water level and similar position devices.

The system transmits impulses, the repetition frequency of which determines the reading. Line characteristics have no effect upon accuracy, and the system will operate over any line capable of transmitting impulses. The impulse frequencies most commonly used are 0 to 66⅔ per minute and 0 to 33⅓ per minute, giving response times of fifteen and thirty seconds respectively, and allowing six and twelve readings respectively to share a channel. The display includes a telemeter operating from an impulse source and indicating the accuracy obtained by using the system. Associated with the telemeter is an electronic distributor which enables a number of meter readings to be transmitted over one telecommunication channel. By means of the distributor the impulses are converted to teleprinter five-unit binary codes operating at a speed of fifty bauds. A receiver accepts the impulses and a synchronised scanner re-allocates the received impulses to their telemeter circuits, which then respond in accordance with the received impulse rate.

The exhibit which was designed to illustrate the system took the form of an illuminated block schematic diagram, incorporating lamp displays to simulate the processes of impulse generation, storage, scanning, coding, decoding and remote indication.

A group of exhibits on the stand was devoted to control and test apparatus. The Standard-Sunbury engine indicator was demonstrated in its latest form which has improved facilities for presenting visual displays of performance characteristics, such as change of pressure and rate of change of pressure. With its improved pick-up assemblies this instrument is capable of indicating information at engine speeds of 80 r.p.m. to about 22,000 r.p.m. with cylinder or fuel line pressures up to about 10,000 lb per square inch or torsional vibrations up to about 60,000 cycles per minute.

Another instrument that was exhibited was the Maximum-Amplitude Measuring Set, which is designed to measure maximum positive peak voltages on one meter and maximum negative peak voltages on a second meter, both deflections being maintained until manually released. It is stated to have an accuracy better than 95 per cent for transients that build up to or maintain their peak values in as little as 1 millisecond.

Evershed and Vignoles, Ltd.

Instruments for maintenance, for supervisory work and for special purposes were shown by Evershed and Vignoles, Ltd., Acton Lane, Chiswick, London, W.4.

Among the instruments for supervisory work was a miniature recorder which has been developed mainly for use with process control equipment ; it is suitable for recording physical quantities such as pressure, flow or level, which are detected and transmitted by various forms of electronic transmitter. The recorder is a moving coil milliammeter with a small continuous-roll chart which is 2in wide and is driven at a speed of ½in an hour by a synchronous motor. The record is made by a high-speed tapping mechanism using an inked ribbon. The overall size of the front of the recorder when flush-mounted in a panel is about 6in by 4in.

Among the special instruments to be seen on this stand is a Tinsley thickness gauge, which is intended as a simple and inexpensive means of measuring the thickness of non-magnetic coatings such as paint on ferrous bases. It consists of a specially light magnet attached to a spring and contained in a pencil-like tube.

To take a measurement the magnet is placed on the testing surface and the body of the gauge is drawn away thus extending the spring. The spring extension, the amount of which is observed on the scale, is proportional to the force required to detach the magnet from the surface. A layer of the non-magnetic material such as paint between the magnet and the ferrous base decreases this force and, hence, the spring extension will be a measurement of the thickness of the layer.

Some Switchgear Exhibits

A 3·3kV, 1200A, 150MVA, single-busbar air break "ASB33" unit suitable for controlling generating station auxiliaries and heavier industrial plant and an 11kV, 250MVA outdoor, oil-immersed fuse switch, combined with oil switches to form a typical ring main unit, were shown by Ferguson Pailin, Ltd., Higher Openshaw, Manchester, 11.

Industrial switchgear and accessories up to 11kV were shown by A. Reyrolle and Co., Ltd., Hebburn, Co. Durham : the exhibits included an 11kV, 250MVA, horizontal draw-out, metal-clad "C6T" panel with a spring-operated oil circuit breaker ; a 440V, 25 MA, metal-enclosed horizontal draw-out air-break circuit breaker, and a 440V, 80A, twin circuit flameproof contactor panel for use in oil refineries.

A new product of George Ellison, Ltd., Perry Barr, Birmingham, 22B, shown for the first time, was the company's 11kV switchboard consisting of an oil circuit breaker with arc control devices, vertical isolation, and mounted on a withdrawable truck ; the circuit breaker is A.S.T.A. tested and is made to comply with B.S. 116 : 1952.

A new range of A.S.T.A. tested h.t. switchgear was also shown by Erskine Heap and Co., Ltd., Broughton, Manchester, 7—a complete 11kV, 150MVA rupturing capacity unit, and an 11kV, 250MVA circuit breaker incorporating "Direct-Blast" arc control.

The exhibits shown by Johnson and Phillips, Ltd., Charlton, London, S.E.7, included a "Trinal TOS" oil switch, designed to facilitate isolation without interrupting supply in ring main units. It is intended for a maximum voltage of 11kV and a maximum current of 600A and to make and carry fault currents up to 250MVA at 6·6kV. The design is such that, under through-fault or short-circuit conditions, the electromagnetic forces set up are used to assist in the closure of the switch.

A control cubicle containing automatic starting and control gear for a motor alternator set (consisting of a 23 h.p. slipring motor, a 21 h.p. d.c. motor, and a 15kVA, 0·8 p.f. alternator) was shown by the Electric Construction Company, Ltd., Wolverhampton ; in this equipment the control gear for the d.c. motor includes an electronic automatic speed regulator. The company was also responsible for an unattended display consisting of a control cubicle fitted with apparatus and instruments for the automatic control of a diesel-engine-driven "No-Break" alternator set as supplied for standby services for telecommunications and other essential supplies. This design of standby control provides for starting up the diesel-engined alternator set, without time lag, in the event of mains failure, and one form of the equipment was described in our issue of May 8, 1953, page 657.

Among the switchgear exhibits shown by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, was a low-voltage, weatherproof rotation switch for safeguardng conveyor systems. This equipment, as described in our issue of March 5, 1954, page 350, consists of a weatherproof case housing two mercury switches, which can be tilted by a camshaft which projects through a packing gland in the side of the case ; the camshaft is coupled to a layshaft on the conveyor system. As the layshaft rotates the camshaft tilts the mercury switches periodically once per revolution. If the layshaft speed falls below a certain value, corresponding to the delay period of the mercury switches, the latter make or break the circuit, giving the required protection to the conveyor.

One of the new products shown by J. A. Crabtree and Co., Ltd., Walsall, was the "D6" hand-operated motor starter for motors up to ½ h.p. This equipment, which was described in our issue of February 19, 1954, page 293, is available as an interior unit for inset mounting and in alternative forms for flush or surface mounting. In each instance the starter is operated by push buttons which afford visual indication of the switching position and the construction incorporates automatic "free handle" release. The adjustable thermal overload releases are provided with ambient temperature compensation.

An interesting form of circuit breaker designed to give automatic earth-leakage protection to domestic and small industrial installations was shown by Chilton Electric Products, Ltd., Hungerford, Berks. It is known as the Current Balance circuit breaker and operates through a differential current sensing system designed to deal with leakage currents of the order of 2A to 3A.

Tees-Side Firm's Centenary.—This year Pickerings, Ltd., Globe Elevator Works, Stockton-on-Tees, celebrates its centenary. This firm was founded in 1854 by a Mr. Jonathan Pickering, who invented and patented a pulley block. In its early years, therefore, the firm was wholly engaged in the manufacture of these pulley blocks. As time went on other hoisting appliances were developed by the firm, including lifts of various kinds, and in 1888 Pickerings, Ltd., designed and built its first electrically-operated lift which was installed at the Middlesbrough Co-operative Society. Since then the firm has specialised in the production of lifts, and also in the manufacture of many forms of handling plant and furnace charging machines. The business was incorporated as a limited liability company in 1887. The present chairman of Pickerings, Ltd., is Mr. John Fothergill, who, in this centenary year, completes fifty years in the company's service.

Electrical Drive for a Planetary Rolling Mill

In our issue of October 23, 1953 (pages 526–27), we described the first commercial installation of a new design of hot strip rolling mill at the works of Ductile Planetary Mills, Ltd. In this mill, the back-up rolls are fitted with planetary rolls, whereby mill slabs are reduced to strip in a single pass through a single stand. We have now received particulars of the electrical equipment, which was supplied by the English Electric Company, Ltd., for the main and auxiliary drives of the mill, as described below.

THE hot rolling mill installed at the Wednesfield works of Ductile Planetary Mills, Ltd., is the first commercial installation of the Sendzimir planetary design of mill. The principle of operation is indicated in the accompanying simplified diagram (Fig. 1). Rolling is a continuous operation and steel slabs 15in wide by 1¼in thick can be reduced to strip 0·040in thick in one pass. This exceptional reduction is made by a single stand having two 24in diameter rolls surrounded by twenty-six planet rolls, each 2in diameter. The inner rolls are driven at a speed of 500 r.p.m., driving the planet rolls by friction, so that the cages revolve at 228 r.p.m.; the planet rolls, therefore, move over the wedge-shaped end of the slab, which is moved forward by feed rolls so that a reduction of about 0·015in is made as each planet roll passes over the end of the slab. It is possible to vary the ingoing speed of the mill between 4½ft and 9ft per minute, and the outgoing speed of the strip between 66ft and 200ft per minute.

The d.c. supply for the motors is taken from a motor generator set (Fig. 2) having three generators and various exciters driven by a 365 h.p. a.c. synchronous-induction motor arranged to give an overall power factor for the mill of not less than 0·95 lagging. The motor generator set and the automatic control gear are installed in a specially ventilated room, while the mill motors, which are installed in the rolling bay itself, are forced ventilated to exclude airborne dust. Details of the motors supplied are given in the accompanying table.

TABLE—*Details of Motors for Planetary Mill Main Drives*

Drive	Motor			Supply
	Type	Rating (h.p.)	Speed (r.p.m).	
Pinch roll	D.C.	7½	750/ 850	Generator 1
Feed roll	D.C.	30	1000/1100	
Planetary roll	A.C. slipring induction	900	495	415V, three-phase, 50 c/s
Planishing roll	D.C.	200	900/1050	Generator 2
Table rolls (two)	D.C.	5	1000	
Coiler	D.C.	15	285/ 500	Generator 3
Feed roll screwdown	D.C.	10	1200/2400	Constant voltage exciter
Planetary roll screwdown	D.C.	5	600/2400	
Planishing roll screwdown	D.C.	10	600/2400	

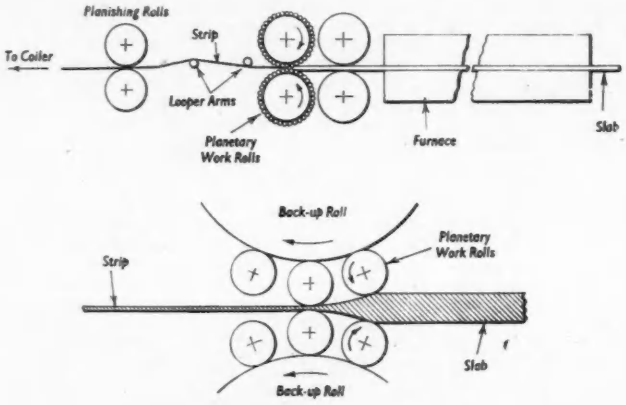


Fig. 1—Arrangement of Planetary Mill

The pinch rolls (Fig. 4) are designed to run at a speed slightly faster than the entry speed of the mill. They are normally open, but are engaged by hydraulic cylinders to the leading edge of each slab to ensure that no gaps exist between slabs before the feed rolls are reached. The feed roll drive is arranged to push the slabs into the planetary roll bite against a thrust of up to 11 tons set up by the rolling action. The pinch and feed roll motors are supplied from a common Ward-Leonard generator.

A slipring induction motor drives the planetary rolls continuously at a constant speed, and is controlled by a circuit breaker and hand-operated liquid starter. To ensure rapid stopping in an emergency, a Thrustor-operated brake is fitted and is operated by the common emergency stop on the control desks.

Another generator supplies Ward-Leonard control of power for the planishing rolls and the two table rolls. The planishing roll motor has a field rheostat to enable its speed to be adjusted to the speed of the strip from the planetary rolls, which is determined by the speed of the feed rolls and the roll setting.

A heavy-duty mill motor provides rapid acceleration and retardation for the three-roll coiler, and is supplied by the third generator. The coiler speed is matched to the outgoing speed of the mill by the use of coupled rheostats in the fields of generators Nos. 2 and 3. When the end of a strip has passed between the planishing rolls, the coiler motor speed is increased by 75 per cent, so that the strip may be completely coiled, the coil ejected, and the coiler rolls returned to mill speed before the leading edge of the next strip reaches the coiler. The two run-out table rolls are adjusted to run at the same speed as the strip from the mill and are not affected by the rapid acceleration of the coiler drive as it coils each strip.

When the mill has been set for a specific programme, the speed of all main drive motors may be varied together over a 2 : 1 range by

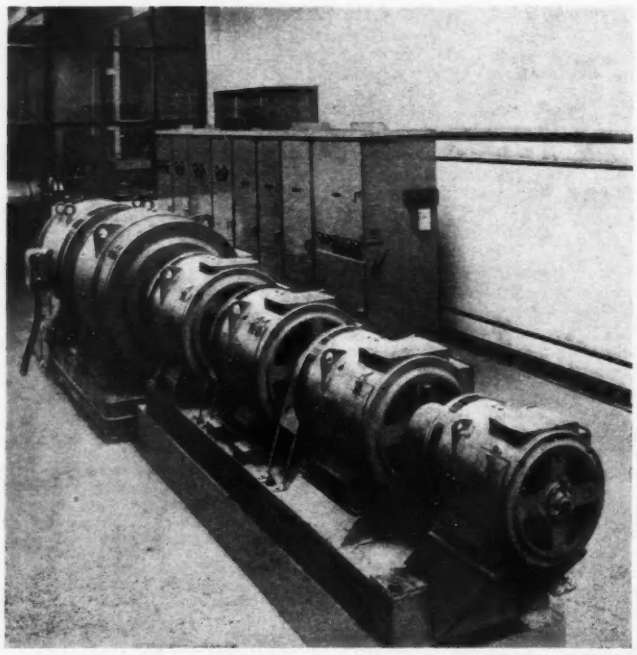


Fig. 2—Motor Generator Set Supplying D.C. Driving Motors of the Planetary Mill. Automatic Contactor Control of D.C. Drives and A.C. Auxiliaries is Effected by the Control Board in the Background

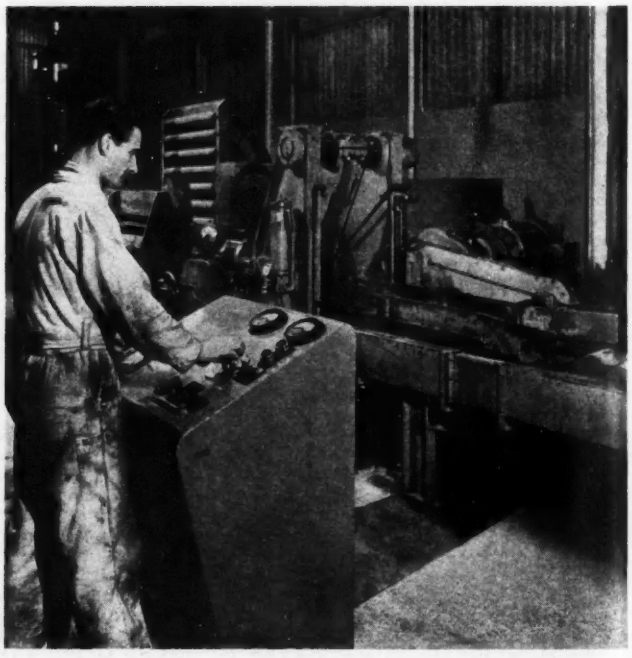


Fig. 3—Control Desk for the Coiler. The Mill-Type Coiler Motor is at the Rear of the Coiler

controlling the output of the small exciter that supplies the fields of the three generators.

Screwdown motors were supplied for the feed rolls, planetary rolls and planishing rolls. The screwdown motors for the feed rolls and planetary rolls have vertical shafts and are skirt-mounted on to bevel gear units that drive the screwdowns through electromagnetic clutches. Electromagnetic brakes are also provided. The planishing screwdown motor has a horizontal shaft and drives through a similar arrangement of bevel gears, clutches and brakes. To ensure accurate adjustment during rolling, and the fast separation of the rolls during an emergency, fast and slow

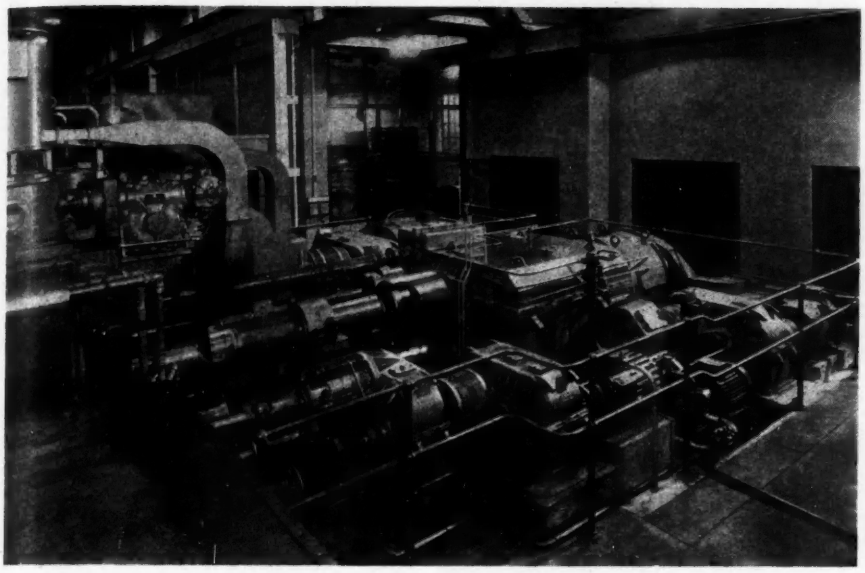


Fig. 4—Motors Driving the Pinch Rolls, Feed Rolls and Planishing Rolls of the Mill. The Feed Roll Screwdown Motor is on the Extreme Left

operation of the motors is provided with automatic current-limit acceleration on field weakening.

Various a.c. auxiliary drives were supplied for such items as lubrication and coolant pumps, roll changing gear, and the forced ventilation fans for the motor generator room and the mill motors.

The mill is controlled from three desks set respectively in front of the feed rolls, between the planetary and planishing rolls, and in front of the coiler (Fig. 3). All the necessary control switches, push buttons, speed regulators and indicating instruments are grouped together on these control desks.

The electrical equipment for the main and auxiliary drives of the mill was supplied by the English Electric Company, Ltd., to the requirements of W. H. A. Robertson and Co., Ltd., which made the mechanical equipment of the mill.

D.S.I.R. Report for 1952–53

THE thirty-eighth annual report of the Department of Scientific and Industrial Research was published at the end of last week. It covers the year ended September 30, 1953, and 213 of its pages are devoted to summaries of the work carried out in each of the research establishments and research associations. The report of the Mechanical Engineering Research Board is divided into parts dealing with each division. In the lubrication and wear division reference is made to the programme of research on the operation of bearings at higher speeds and on the elucidation of some fundamental aspects of the wear process. Pending the construction of two machines of 100 h.p. output designed to operate at speeds up to 60,000 r.p.m., experiments have been carried out on small-scale apparatus running at moderate speeds. This, it is stated, has demonstrated the effectiveness of the air gauging method for measuring attitude and eccentricity of journal bearings, but has revealed that bearings may tilt as loading conditions are changed. Friction torque at a given speed has been shown to be virtually independent of load, whilst the amount of oil demanded by a bearing increases both with speed and load. As speed is increased the amount of heat dissipated in the lubricant also increases. Its viscosity consequently falls and this causes eccentricity to increase, thereby increasing the pumping action of the bearing so that equilibrium conditions are restored. The implications of these effects are being explored for the benefit of designers. The study of the behaviour of roller bearings at relatively high temperatures has been continued; bearings have been run at speeds of 20,000 r.p.m. for about thirty hours at a temperature, measured at the inner race of the bearing, of 300 deg. Cent. Conventional mineral-base lubricating oils failed to withstand these conditions, the report notes, and synthetic lubricants specially developed for use in gas turbines were shown to be necessary.

The actual mode of action of a grease in lubricating a bearing has hitherto received little attention. By a theoretical consideration of the rheological aspects of lubrication, with lubricating grease regarded as a Bingham fluid, it has been possible to write down equations governing its action in a bearing which are analogous to Reynolds' hydrodynamic equations. An important conclusion of this work is that the plastic viscosity rather than the apparent viscosity becomes the important criterion of grease as a lubricant. In a second investigation, new and used greases have been examined in the electron microscope. This has shown that in grease taken from different parts of a roller bearing after varying times of operation the fibre structure characteristic of a lubricating grease is rapidly broken down in those parts of a bearing where the grease is subject to severe working.

Wear.—It has been suggested by Kramer in Germany that metal surfaces which have been abraded or otherwise worked emit electrons over a period of time. The emission can be detected by a special Geiger counter open at one end. Investigations in the Laboratory have demonstrated that the particles which actuate the counter are not electrons, but charged oxygen molecules. Their rate of emission from an abraded surface is very much increased if energy in the form of light of a particular wavelength is supplied to the surface. Experiments on the true nature of these emissions have led to the tentative conclusion that they arise from the oxide structure formed at the surface during the process of abrasion.

A parallel investigation has shown that the blackening of a photographic plate when placed close to an abraded surface is due to the formation of hydrogen peroxide near the freshly abraded area. It has also been shown that metals when cut under water give rise to the formation of hydrogen peroxide. It is thought that the emissions referred to previously are the cause of the formation of this peroxide.

Practical implications of the work in the realm of lubricant technology are twofold. In the first place, it is possible that the action of abrasion may produce chemically modified surface layers on bearing metals which account for their wear resistance; furthermore, the formation of peroxides on freshly worked surfaces may be a contributory factor in the deterioration of lubricating oils in service.

From the summary of work at the National Physical Laboratory it is noted that diffraction gratings made by the Merton-N.P.L. processes are being applied to accurate linear measurement by a "fringe counting" method especially suitable for the automatic control of machine tools, and a lathe of unique design, made by a London firm under the supervision of the Metrology Division, has been acquired, and is undergoing tests. It is a dual-purpose lathe capable of diamond turning metal cylinders to a high-quality finish, but its principal function is to produce screw threads as fine as 30,000 threads per inch, upon a bar 4in diameter and 24in long, the maximum size that can be dealt with. Such a thread measures over 140 miles in length. It is not yet known, the report states, if any diamond tool will run such a course without blunting.

In the report of the British Electrical and Allied Industries Research Association it is stated that a comparison between the response of two large floor heating installations, one using buried water pipes and the other buried electric conductors, has been made. It has also been established that a dual-purpose heat pump cooling a domestic larder and providing at least 500 gallons of hot water per week for one-third of the normal electricity consumption is a practical possibility. General heat pump investigations continue; the 10 h.p. installation at Shinfield has now operated satisfactorily throughout two heating seasons using only the earth as a heat source. Progress in the investigation of "latent-heat" storage is encouraging. It has been found possible to store heat and release it at constant temperature over a period consisting of some hundreds of six-hourly cycles. The bulk of material necessary is much less than for specific heat storage, as with water concrete, &c. Methods of control are being studied. The report is published by Her Majesty's Stationery Office, price 8s.

Rolling Stock for South African Railways

ACCORDING to the general manager's report, an increase of 8·5 per cent in the traction force at the disposal of the South African Railways is expected during the current financial year ending in March. A further increase of 10·3 per cent is expected during the 1954–55 period. This improvement can be expected because some long outstanding orders for locomotives are now being carried out, while some more recent orders are also being executed according to scheduled delivery dates. The truck position, which took a favourable turn a few years ago, is still improving. Merchandise-carrying truck capacity advanced by 5·2 per cent during the course of the present financial year, and another 4·1 per cent advance is expected during 1954–55. The number of new trucks being added every month is satisfactory, while substantial orders remain to be carried out by suppliers. Reviewing the financial record of the first six months of the Railway's financial year, this reflects a marked decrease in expenditure in comparison with the estimates. Instead of £69,134,216, as originally estimated, the actual expenditure was £65,573,076, a saving of £3,561,140. Throughout this period more passengers and a greater tonnage of goods were carried than in the corresponding period last year. The saving is reduced to some extent by higher cost-of-living allowances which became payable as from April 1st. But even when this amount of £1,303,563 is deducted, there is still a reduction in expenditure of £2,257,577.

Metallurgical Topics

Precipitation Hardening in an Austenitic Steel

DURING an investigation of austenitic steels for exhaust valves, it was found that 21 : 12 chromium-nickel steel containing about 0·5 per cent of carbon could be hardened by a solution and ageing treatment to a hardness of nearly 400 DPH provided that a very high solution temperature was used. It was also found that the addition of about 0·3 per cent of phosphorus to the high-carbon austenitic steel caused the steel to harden appreciably when a much lower solution temperature was used than that necessary to develop high hardness in the low-phosphorus steel. Work arising from these observations has been described by A. G. Allten, J. G. Y. Chow and A. Simon,* who have investigated two series of steels containing chromium 21 and nickel 12 per cent—one with phosphorus 0·03 per cent and carbon 0·3, 0·5 and 0·7 per cent, and the other with carbon 0·5 per cent and phosphorus 0·03, 0·16, 0·3 and 0·5 per cent. The steels, which were induction melted, were cast as 15 lb ingots and forged to ⅝in square bar. They all contained 0·07 to 0·08 per cent of nitrogen (in the 0·3 per cent carbon low-phosphorus steel,

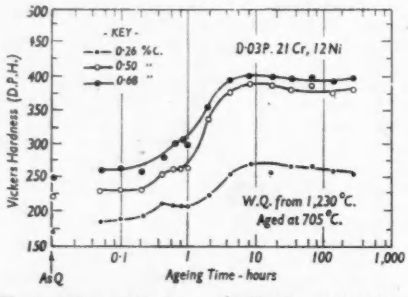


Fig. 1—Effect of Carbon on the Hardness of 0·03 per Cent Phosphorus, 21 : 12 Chromium-Nickel Steel, Solution Treated One Hour at 1230 Deg. Cent, Water Quenched, and Aged at 705 Deg. Cent. (Allten, Chow and Simon)

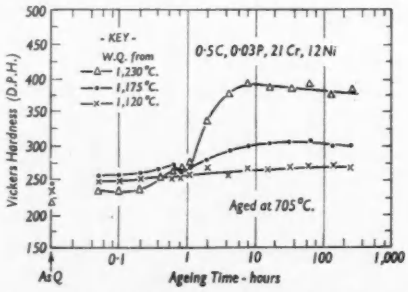


Fig. 2—Effect of Solution Temperature on the Hardness of Steel Containing Carbon 0·5, Phosphorus 0·03, Chromium 21 and Nickel 12 per Cent, Aged at 705 Deg. Cent. (Allten, Chow and Simon)

0·10 per cent), but its presence was not regarded as significant. The solution treatments, applied to specimens about 1in long from each of the steels, consisted of heating for one hour at 1120 deg., 1175 deg. and 1230 deg. Cent., followed by water quenching to room temperature. Ageing was carried out at five temperatures between 595 deg. and 815 deg. Cent.

The hardness obtained in the three steels of varying carbon content, with 0·03 per cent of phosphorus, is shown in Fig. 1. Both the 0·5 and the 0·7 per cent carbon steels contained residual carbide after solution treatment at 1230 deg. Cent. showing that in each case the austenite was saturated, but in the 0·3 per cent carbon steel all the carbide had dissolved. Thus, the 0·5 and 0·7 per cent carbon steels show nearly the same increase in hardness after ageing, whereas the 0·3 per cent carbon steel hardens to a much smaller degree. The amount of carbon dissolved is affected by the solution-treatment temperature, and considerably higher hardness is obtained after water quenching from 1230 deg. Cent. than after water quenching from 1175 deg. Cent., while solution treatment at 1120 deg. Cent. is ineffective in the low-phosphorus steels (Fig. 2). The effect of additions of phosphorus on the age-hardening behaviour of the 0·5 per cent carbon 21 : 12 chromium-nickel steel is illustrated in Fig. 3. Solution treatment was at 1175 deg. Cent., as, with a phosphorus content of 0·3 per cent and over, a liquid phase was formed at the higher solution-treatment temperature. Similar, but smaller, increases in hardness resulted after water quenching from 1120 deg. Cent. Thus, in the presence of high phosphorus, much greater hardness could be obtained in a shorter ageing time with a lower temperature of solution treatment, and softening, due to over-ageing, set in sooner. Several curves are given in the paper showing changes in hardness produced by holding the specimens at various ageing temperatures for periods up to several hundred hours. All these resembled curves typical of a precipitation hardening process. The curves for the 0·5 per cent carbon, 0·5 per cent phosphorus steel are shown (without the individual readings) in Fig. 4. This steel was less affected by rate of cooling after solution treatment than the low-phosphorus steel. The 0·5 per cent carbon low-phosphorus material, when air cooled after solution treatment at 1175 deg. Cent., attained a hardness of only about 260 on ageing, compared with 360 when water quenched, but air cooling instead of water quenching from 1175 deg. Cent. made no appreciable difference to the hardness (about 480) reached after ageing by the 0·5 per cent carbon 0·5 per cent phosphorus steel. Thus, the phosphorus-rich solid solution does not break down even at relatively slow rates of cooling and it may therefore be possible to harden the high-phosphorus material in relatively large sections.

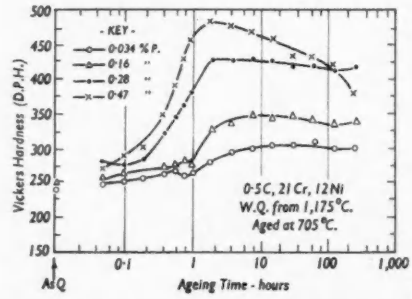
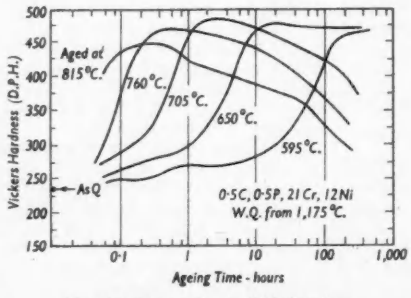


Fig. 3—Effect of Phosphorus on the Hardness of 0·5 per Cent Carbon 21 : 12 Chromium-Nickel Steel, Solution Treated One Hour at 1175 Deg. Cent., Water Quenched, and Aged at 705 Deg. Cent. (Allten, Chow and Simon)



The original curves show individual readings.

Fig. 4—Effect of Ageing Temperature on Hardness of 0·5 per Cent Carbon, 0·5 per Cent Phosphorus 21 : 12 Chromium-Nickel Steel, Solution Treated One Hour at 1175 Deg. Cent. and Water Quenched (Allten, Chow and Simon).

Although phosphorus exerts so great an influence on precipitation hardening in 21 : 12 chromium-nickel steels, and gives an increased degree of dispersion of the precipitate, there is no evidence of the separation of a phosphorus compound. The only precipitate detected in either the high or the low phosphorus steels was a carbide having the structure of the cubic chromium carbide $Cr_{23}C_6$. A tentative explanation, based on the assumption of an increase in the strain energy in the austenite lattice by interstitially dissolved phosphorus is put forward by the authors.

The question naturally arises as to whether practical advantage can be taken of the great increase in hardness which may be obtained in this steel. The authors' investigations do not throw any light on this point, and it is very desirable that the general properties of the high-phosphorus steels should be studied. The fact that precipitation hardening by carbide is possible in austenitic chromium-nickel steels has long been known, but in the usual low-carbon 18 : 8 variety a hardening treatment by precipitation of carbide is impracticable, as the carbide does not separate as a fine dispersion within the grains, but as a film in the grain boundaries, giving little increase in hardness, but rendering the steel susceptible to intergranular attack. In the high-carbon steels it is possible that both forms of precipitation occur : some of the authors' photomicrographs are not very reassuring as to the absence of a grain-boundary film. Moreover, the degree of precipitation hardening shown is almost certainly accompanied by considerable brittleness. The authors' important observations must remain of academic interest until further work is done to ascertain to what extent practical advantage may be taken of the increased hardness obtained by solution treatment and ageing of these high-carbon, high-phosphorus austenitic steels.

American Society for Metals

MOST of the sixteen papers presented at the meeting of the American Society for Metals, held at Boston on March 3 and 4, 1954, dealt with modifications of the properties of carbon and alloy steels brought about by variations in composition and heat-treatment. The following is a brief abstract of some of the papers having reference to materials of engineering interest.

EFFECT OF ALUMINIUM AND NITROGEN IN STEEL

The importance of aluminium nitride in relation to the structure and properties of low-carbon deep-drawing steels was shown in a paper by W. C. Leslie *et al.* (1W).* For some time it has been known that the grains of an aluminium-killed low-carbon sheet steel might be either equiaxial or elongated. It was found that the ferrite grain size was influenced by the precipitation of aluminium nitride from solid solution during heating to, or at, the annealing temperature (e.g. 650 deg. Cent.). The temperature required for complete solution of AlN is high (about 1095 deg. Cent.) and precipitation is most rapid at 815 deg. Cent. Substantially complete precipitation of AlN in the hot-rolled strip diminishes the tendency to form elongated grains in the cold-reduced box-annealed sheet. It was also found that elongated grains were produced in aluminium-killed sheet steel only when the acid-soluble aluminium content was between 0·015 and 0·08 per cent. Below this range there was not enough aluminium to combine with the nitrogen to ensure a fairly uniform distribution of nitride, and aluminium above 0·08 per cent produced nearly complete precipitation of the nitride before the annealing stage was reached. This work on aluminium nitride has an interest also in connection with strain ageing and notched-bar impact values of low-carbon steels. It also

* "Precipitation Hardening in Austenitic Chromium-Nickel Steels Containing High Carbon and Phosphorus," American Society for Metals, 1953 Preprint No. 10W.

* The figures following authors' names refer to the number of the American Society for Metals, 1953, Preprint.

has a bearing on the formation of graphite in steels. E. J. Dulis and G. V. Smith (2W) described the role of aluminium in promoting graphitisation in a 0·8 per cent carbon steel. Nitrogen by some means inhibits the breakdown of cementite. A purified iron-carbon alloy low in nitrogen (less than 0·001 per cent), containing no detectable aluminium, graphitised readily, whereas the same alloy containing about 0·03 per cent of nitrogen did not form any graphite after the same treatment. The susceptibility to graphitisation in commercial steels containing aluminium and nitrogen was decreased by nitrogen in excess of that required to form AlN. It was thus concluded that the role of aluminium in graphitisation was that of a scavenger for nitrogen.

Grain Size Effects

As a result of their work on high-purity iron-carbon alloys, substantially free from oxygen and nitrogen, R. L. Smith, G. Spangler and R. M. Brick (3W) found that the ferrite grain size of 0·02 per cent carbon alloys was the sole factor determining their ductility at liquid air temperatures. Decrease in grain size caused a considerable increase in ductility. With more than 0·02 per cent carbon the form of the carbide had an important effect, and liquid air ductility was determined both by grain size and by the state of the carbide. Heat-treatment above the critical range, which resulted in carbide or pearlite at the ferrite grain boundaries, reduced the low-temperature ductility. Sub-critical annealing of cold-worked material, giving spheroidised carbides, eliminated the detrimental effect of carbide, at least in the direction of rolling, and left the grain size effect predominant. Twinning was not found to contribute to low-temperature brittleness.

Grain size affects the fatigue limit of materials to about the same extent as it affects the tensile strength. In steel the effect is slight ; in brass it is more important. J. E. Breen and J. R. Lane (13W), experimenting with alpha brass, found that at room temperature and at 290 deg. Cent. fine-grained material was superior in both fatigue and stress rupture tests. At higher temperatures the superiority of fine-grained material in fatigue progressively decreased, and at 540 deg. Cent. the difference was very slight though the endurance of the fine-grained material never fell below that of the coarse-grained material. Stress rupture tests also showed the superiority of fine-grained material at the lower-temperatures, but at the higher temperatures there were combinations of stress and temperature at which the coarse-grained material was stronger.

Hardenability

For many years hardenability factors a nd end quench tests have been increasingly used by metallurgists, and the time seems appropriate for the reassessment of some of the principles and methods involved. Accordingly, D. J. Carney, of the U.S. Steel Corporation, has taken "Another Look at Quenchants, Cooling Rates and Hardenability" (5W), as a result of which improved hardenability correlation curves have been suggested, including an improved curve for correlating the ideal critical diameter with distances on the Jominy end-quench bar. J. Birtalan, R. G. Henley, jun., and A. L. Christenson (6W) have investigated factors which affect the reproducibility of the Jominy end-quench test. Their general conclusion was that, while adherence to certain procedures is necessary and certain precautions (which are listed) must be observed, the end-quench test has excellent reproducibility and is certainly reproducible to such an extent that most of the disagreement among laboratories must be the result of inadequate standardisation of technique and equipment, and not lack of reproducibility of the test.

The end-quench test is capable of many applications, and modifications have been introduced from time to time both in type of materials tested and in the conditions of the test. C. M. Carman, D. F. Armiento and H. Markus (7W) have developed a Jominy type of hardenability test in which molten salt at 205 deg. Cent. is used as the quenching medium. Shallow-hardening steels showed little increase in hardness under these conditions. Steels of intermediate hardenability showed a reduced response when compared with their behaviour in the standard Jominy test, i.e. the fall in hardness occurred nearer the quenched end of the bar. In deep-hardening steels the response was almost the same as in the standard water quenching test. By the use of molten salt it was hoped to assess the suitability of a steel for marquenching—a heat-treatment which can be applied to complex steel parts which cannot be hardened by conventional methods without distortion or cracking. The results of the test may, however, be greatly influenced by film effects which are not well understood at present.

The Martensite Transformation

Evidence about the effect of austenitising temperature, austenitic grain size and rate of cooling upon the temperature at which the martensite transformation starts (M_s) is somewhat conflicting, and M. R. Meyerson and S. J. Rosenberg (8W) have determined the effect of these variables on the M_s temperature of two 0·5 per cent carbon steels. The M_s temperature was found to increase with increasing austenitising temperature, but this was probably due to the larger grain size produced. For example, after austenitising at 800 deg. Cent. (A.S.T.M. grain size 8) M_s was 305 deg. Cent.; after austenitising at 1175 deg. Cent. (grain size 2) it was 325 deg. Cent. Changes in rate of cooling, over the range 780 deg. to 2780 deg. per second between 705 deg. and 480 deg. Cent., had no effect on the M_s temperature.

The evidence, however, still remains conflicting. Almost simultaneously with the publication of this paper, C. L. M. Cottrell† has reported that in a 3½ per cent nickel-chromium-molybdenum steel M_s, after remaining constant at 325 deg. Cent. at relatively slow rates of cooling, is progressively lowered to about 285 deg. Cent. by faster rates. He also concluded that raising the austenitising temperature from 1240 deg. to 1330 deg. Cent. had no effect on M_s, though, judging from his curves, it may have induced a rise of about 5 deg. Cent. in the constant value at the slower rates. It seems possible that in steels of lower alloy content the M_s temperature may remain constant at faster rates of cooling. Much faster rates were used by Meyerson and Rosenberg, but these were apparently not sufficiently great to cause lowering of M_s in carbon steels.

High-Alloy Austenitic Steels

An interesting paper on precipitation hardening in austenitic steels containing carbon and phosphorus, by A. G. Allten, J. G. Y. Chow and A. Simon (10W), is reviewed in more detail in another column. A dark needle-like constituent may sometimes be observed in 25 : 12 and 25 : 20 chromium-nickel steels, and R. C. Frerichs and C. L. Clark (9W) have carried out an investigation to determine the relationship between this constituent, the nature of which is still uncertain, and sigma, and to study the formation of the sigma phase in these steels, as affected by grain size, time and temperature. Both constituents form in the same general temperature range and both tend to decrease the impact resistance. The tendency towards the formation of both constituents is greater in the 12 per cent nickel alloy than when 25 per cent of nickel is present. Ageing experiments extending to 1000 hours at temperatures between 620 deg. and 900 deg. Cent. indicated that the formation of sigma was more rapid in fine-grained than in coarse-grained structures, whereas in coarse-grained specimens the needle-like constituent, presumably carbide, was prevalent. The coarse-grained water-quenched alloys had the better properties, though it was not implied that they were necessarily superior for high-temperature applications.

Most engineering materials strain harden as a result of plastic deformation, even at high temperatures, provided that the rate of strain exceeds the recovery and recrystallisation rate. For example, mild steel, even at 1250 deg. Cent., has a rising stress-strain curve if the rate of strain is high enough. Tests made by D. A. J. Millar and J. Wulff (12W) showed that the Timken alloy, the 16 : 25 : 6 chromium-nickel-molybdenum iron-base alloy, even in the fully annealed condition, was softened by further straining at 980 deg. to 1205 deg. Cent. The probable cause of the softening was held to be the solution of some of the grain boundary precipitate during deformation. Reprecipitation along the deformation planes gave increased strength on ageing. The 16 : 25 : 6 alloy is extensively used in turbine rotors and discs, but 25 per cent of nickel has to be used to keep it in the austenitic condition. The possibility of replacing some of this nickel by manganese has been investigated by W. E. Ellis and M. Fleischmann (11W), who compared the standard alloy with one in which 10 per cent nickel had been replaced by an extra 6 or 7 per cent of manganese. Mechanical tests at room temperature, and presumably also at moderately raised temperatures, were similar for the two alloys ; but the alloy containing manganese was inferior to the standard 16 : 25 : 6 beyond 1000 hours at 760 deg. Cent. when solution quenched, and at 650 deg. Cent. in the hot-rolled and tempered condition.

Other Papers

There were also papers dealing with interstitial solid solutions, anisotropy in copper, and with creep and tensile properties of aluminium and of aluminium-copper alloys at raised temperatures.

Hydrogen in Steel

Attention may be directed to an excellent account of "The Significance of Hydrogen in Steel Manufacture," by K. C. Barraclough, of the Brown-Firth Research Laboratories, which has recently appeared in the *Murex Review*.* It covers methods of determination of hydrogen in steel, the sampling of liquid steel, effect of composition on the solubility and rate of diffusion of hydrogen in solid steel at different temperatures, and the storage of samples under conditions which prevent evolution of hydrogen or in which the hydrogen evolved during storage is collected. Information is also given about the hydrogen content of various types of steel produced by different steel-making processes, the sources from which the hydrogen in steel is derived, and precautions which can be taken to ensure that a heat of steel has as low a hydrogen content as possible. The effect of hydrogen on the solidification of the ingot is described with numerous illustrations of ingot sections showing the types of unsoundness produced when hydrogen is too high for complete solubility ; though when the hydrogen content is below this limit other conditions may combine to produce porous or even wild casts.

These subjects, of great importance to the producer of high-quality steel, occupy about two-thirds of the paper. The remaining third is devoted to the after-effects of failure to secure the correct conditions in manufacture, i.e. the influence of hydrogen in solid steel. Provided that an ingot free from porosity is obtained, hydrogen has no noticeable effect in austenitic steels. In low-alloy and carbon steels, however, its effects may be very pronounced, the most definite being "hydrogen embrittlement" or the lowering of ductility as measured by elongation and reduction of area. Numerous examples are given of the progressive lowering of ductility with increase in hydrogen content, the improvement in ductility brought about by storage at room temperature, and its complete recovery by heating to a temperature, which in the case of a very large forging may be as high as 650 deg. Cent. The embrittling effect of hydrogen is rarely observed in bars of small diameter as diffusion occurring during normal treatment in manufacture reduces the hydrogen content to a low value ; but another deleterious effect, closely related to hydrogen content, remains, viz. susceptibility to the formation of hair-line cracks. The incidence of hairline cracks in relation to the hydrogen content of the steel is discussed, and the evidence tends to support the contention that hydrogen is responsible for the formation of these cracks, though other factors also may have a significant effect.

This short paper should appeal to all those interested in the properties of steel as a concise and authoritative review of a subject, the importance of which has been realised by metallurgists for many years.

† *Journal of the Iron and Steel Institute*, March, 1954, page 269.

* *Murex Review*, No. 13, 1954. Published by Murex, Ltd., Rainham, Essex.

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BI-CENTENARY OF THE ROYAL SOCIETY OF ARTS

As the centuries roll by so do words change their meanings. To-day a reference to arts brings first to mind painting, sculpture, music, architecture, and the drama. But it was not so two centuries ago. Then the word "art" commonly had a meaning almost synonymous with "skill," and it could be applied, as it is more rarely applied to-day, to mean anything wherein skill may be attained. Thus it is needful in these days not to be led astray by the title of that remarkable body, the Royal Society of Arts, which has this week been celebrating its bi-centenary; nor to imagine that the breadth of its interests are as circumscribed as its title and its object of "encouraging Arts, Manufacture and Commerce" might suggest. In fact there is hardly any human activity into which skill does not enter and which cannot therefore be regarded as coming within the cognizance of the Society. Its members are as much at home listening to a lecture by a scientist or a technologist as they are in having the beauties of works of art displayed before them. Nor, fortunately are they above mixing science and art together, as when they recently had presented to them a discourse on the "Science of Musical Instruments." How many engineers, we wonder, appreciate that here is a Society which, long before even the Institution of Civil Engineers was founded, was already interesting itself in all kinds of engineering and industrial fields as well as more directly artistic ones ?

Last week Mr. A. C. Hartley contributed to our pages an excellent article describing shortly and with emphasis upon its engineering activities the work of the Society during its two hundred years of existence. This week there has been published a remarkably interesting book by Derek Hudson and Kenneth W. Luckhurst (the latter the present Secretary of the Society), in which its history is more fully set out. What a large part the article and the book reveal the Society to have played in English development ! Yet how little credit has been given it ! Again and again throughout its history the Society has deemed its work well done when the interest and enthusiasm of others has been aroused, and it has gladly stood back to leave the field to them. For it has never desired to acquire the specialised knowledge without which great advances cannot be made. It has held fast to its conviction that there is a place for a body without specialised knowledge, yet interested in almost all human activities. One cannot therefore look to the Society, as it is to-day, to attract the kind of technical papers appropriate for presentation before more specialised institutions ; nor can one expect its members to engage in deeply technical discussions or specialised activities. The strength of the Society, that strength which has allowed it to flourish for 200 years despite a lack of wide public appreciation of its value, has lain and still lies in this width of culture, unexampled in any other body. Here is a Society so fundamentally embracing that for it there is no artificial division between the arts on the one hand and the sciences on the other. A paper in either field is equally welcome and equally open to comment from either hand. Of course, papers presented before such a body cannot delve deeply into technicalities. But no man is the worse for attempting to portray his specialist activities before a lay audience. Before an audience as distinguished as the Society can provide he is, indeed, likely to be the better for it ; if only because his specialist techniques and specialist activities will be related by his audience to the ordinary activities of ordinary men, to the living of life rather than to the acquirement of still more specialised knowledge. By consequence its members have repeatedly discerned how specialist enthusiasm has led to the neglect of other advances equally valuable for the human race and have been able to take action to rectify the situation. Almost from the day of its creation, for example, the Society showed concern for the health of workers at a time when few industrialists paid much attention to it ; and before a century had passed it had become active in promoting education for industrial workers. Very early it was offering awards for inventions leading to the improved safety of industrial operations. A conviction that industry was giving too little attention to the æsthetic qualities of its products led up, when the Society took remedial action, to the holding of the Great Exhibition of 1851.

It has been said of the Royal Society of Arts that it has been England's "fairy godmother." How apt the description is seen to be when the history of the Society is read ! Fairy godmothers seldom seek much for themselves. Again and again in the past the Society has provided an impulse which, being taken up by others, has benefited the nation. Whether by offering awards to inventors of machinery, offering encouragement for the growing of medicinal rhubarb, helping along a scheme for supplying fresh fish to London by road transport, organising exhibitions, taking a hand in educational development, attempting to standardise musical pitch, preserving ancient cottages, advocating improvement in industrial design, organising conferences about water supply, sewage disposal and water and air pollution, and directing attention to various subjects by organising lectures and holding meetings, the Society has constantly been engaged in doing something beneficial and godmotherly. Nor has the other side of godmotherly activity been neglected. Fairy tales are nothing if not moral ; and fairy godmothers are never beyond criticising the children they benefit. There, too, the Society plays its part. But it would be an exaggeration to suggest that it acts by discussion and criticism as the nation's conscience. What it does is to set before its distinguished and well-connected members an admirably balanced and candid picture of the activities of the people of this country. No people, perhaps, can better benefit from seeing that picture than engineers, upon whose work society so much and so increasingly depends for its existence. What engineers do, what advances they make are not solely their concern. It is well that, besides their own institutions, where comment will be technical, there is another whose members can relate their activities to those of the community as a whole. We, closely approaching the celebration of our own centenary, salute a Society so very much our senior in the engineering field and congratulate it upon the attainment of its 200th birthday. We believe the Society can play in this age, just because it is an age more technical and specialised than that into which it was born 200 years ago, an even more intensely valuable part than it has played in the past.

EXPERIENCE WITH BRITISH STANDARD LOCOMOTIVES

Events have moved slowly, but, we think, significantly in the British locomotive world since the nationalisation of the railways in 1948. The first main line diesel-electric unit to run in this country was completed early enough for it to bear the initials L.M.S. on the side sheets ; others were building, and a large-scale trial of diesel-electric traction for heavy express passenger working had actually been decided upon by the former L.N.E.R. With the extraordinary example of the American railways before us nothing would have seemed more natural to an onlooker than for the newly-formed Railway Executive to standardise on diesel traction from the outset. We know, however, that Mr. Riddles and his staff, for very good reasons, decided on a totally different course, and the subsequent thermodynamic trials of diesel and gas turbine locomotives on order at the time of nationalisation have certainly vindicated this course on the grounds of fuel costs alone. For main line working Mr. Riddles put his faith in the old faithful, hard-slogging, steam locomotive, and in more than one address there were hints that he expected it to remain the basic form of motive power in this country for many years to come. It is in this respect that views now seem to be changing. In his Presidential Address to the Institution of Locomotive Engineers last autumn Mr. R. C. Bond showed that large-scale electrification was a logical way of dealing with the ever-present difficulties of locomotive coal supplies, and now, in his recent paper covering experiences with British Railways standard types, Mr. E. S. Cox goes so far as to suggest that these locomotives may well be the last complete series which any administration will prepare for steam traction, "having regard," he says, "to the writing on the wall." At a later stage in his paper he does concede that the liquidation of 19,000 steam locomotives is bound to take a number of years, and that in the meantime a certain amount of new construction will be justified. In using such a phrase as "the writing on the wall" we presume he is referring only to British Railways.

On the other hand, the interests of the Institution of Locomotive Engineers are worldwide, and in many parts of the globe the steam locomotive is still in a very healthy stage of development, in both working efficiency and tractive power—thanks largely to the enterprise of the locomotive manufacturing firms of this country. Interest in Mr. Cox's paper will vary. The engineers of overseas railways who naturally look to Britain, as in years gone by, for example and inspiration will not find a great deal to guide them in the future, particularly as those members of the B.T.C. staff now entrusted with design work are having to glance uneasily over their shoulders towards "the writing on the wall." The partisans of one or other of the former main line companies will study the comparisons in performance between the new B.R. locomotives and various Regional types, and all will read with something of concern the rather long list of troubles that has beset the new engines. The thermodynamic performance of the "Britannia" class 4–6–2s, and of the new "class 5" 4–6–0s under carefully controlled conditions, appears to be very good, though not measurably superior to that of certain Regional types on which "full-dress" trials have recently been conducted. Indeed, the data set out in Mr. Cox's paper emphasise the close identity in efficiency between simple expansion locomotives working in the initial temperature range of 670 deg. to 750 deg. Fah., in spite of wide differences in general arrangements. Whether they have twin or multi-cylinders, large or small wheels, wide or narrow grates, and despite considerable variations in back pressure, a minimum steam consumption of 13 lb to 14 lb per i.h.p. hour encompasses them all. For simplicity the new British standard types so far built all have two cylinders, but in comparing their performance with certain three and four-cylinder Regional types we feel there will be many who will disagree with Mr. Cox over his conclusion on this particular point. "There is no hesitation," he says, "in using multi-cylinders where the required tractive effort cannot be contained within the loading gauge with two cylinders. No other reason requires more cylinders, except for the personal fancy of the designer."

Optimum performance, however, whether on the stationary testing plant or in a controlled road trial, is not the ultimate yardstick of locomotive efficiency, and there is no disguising the fact that the new standard types, particularly the "Pacifics" of the "Britannia" class, have so far been troublesome engines, with broken pistons, loose wheels, bent side rods, and cracked frames as the more serious items. The story of these failures, in Mr. Cox's paper, makes intensely interesting reading, and concerning the new engines generally, he comments that while some features, "adopted in fear and trembling, have never given a moment's anxiety," others "thought from past experience to be as reliable as a rock have proved to be shifting sands indeed." But although he discusses thermodynamic performance, and the various troubles with the utmost frankness, Mr. Cox does not touch on the really significant point on which the justification or otherwise of this range of locomotives will ultimately rest : are they giving better all-round service than the regional types of comparable power ? This question covers such points as the reduction of work needed on them at running sheds, reduction in repair costs, increased availability for train working, longer mileages between periodical repair, and so on. All these objects were prominently in view at the time of construction, but from Mr. Cox's silence on the subject we should imagine that insufficient data have so far been collected to make any such comparisons really fair. But having regard to Mr. Cox's remarks about "writing on the wall," and having vividly in mind the troubles that have beset the introduction of the new locomotives a cynic might well be pardoned for doubting if the designing of a new range was worth while at all. One could imagine him asking whether, in view of the short expectancy of life of steam traction in this country, it would not have been better to leave the regions to continue their own existing standards rather than impose new ones all round. Certainly it would seem that there is little chance of the new "standards" becoming really standard within the expected lifetime of the British steam locomotive. Mr. Cox himself remarks: "Controversy naturally surrounds this question . . . . . lest in exchanging four lines of development for one something valuable might be lost." In many respects we know that the pooling of ideas between men of the former independent companies has been very fruitful, and over the question of the new standard locomotives the verdict will no doubt be given before many more years have passed.

Literature

Workshop Costs and Costing. By P. S. HOUGHTON. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 35s.

A LARGE number of books have been written on the important subject of costs and costing, written by cost accountants, who all too often seemed to imply that their particular responsibility was the main function in an organisation. It is all to the good, therefore, to have a work written by an engineer who realises the necessity of good cost accounting, but at the same time appreciates that its purpose is "to assist the management to control the many aspects of the particular concern," indeed it should be its painstaking handmaid. The author points out that there is often a marked difference between what a manager wants to know and what he should know, but when a good system is installed he will find the two coming into agreement. We are told that even after its inauguration a number of unintelligent questions will be asked ; we suggest that a round table conference of all concerned down to the lowest clerk, and a free discussion beforehand will tend to reduce the number of such questions to a minimum.

In the sixteen chapters we are shown how price variation may be accounted for and how a good costing department should help ; then we come to the differentiation between direct and indirect expenses, and all the items that are met with in costing, and the personnel concerned, followed by the proper allocation of oncosts, while two chapters are devoted to the way in which a costing system may be created for a new business, and a further two to foundry costing, a very important matter. The value of the application of codes is stressed, and the way in which graphs may assist is indicated. Contract as well as similar costing, and process costing, are satisfactorily handled. Certain extraneous subjects are introduced, such as the different methods of payment, including daywork, piecework, premium bonus schemes, and profit sharing, all part of management rather than costing. The heading of a chapter, "Financial and Cost Accounts Reconciliation," comes as rather a shock, for we are strongly of opinion that the two accounts should not be at variance, there being no need for reconciliation. The two should be interlocked. The author carefully explains the different methods employed for recovering oncosts, but does not show any marked preference. We feel he might have suggested that the machine-hour rate method, if applied judiciously, should give the best results in a large engineering works. The book concludes with a number of useful questions based on the subject matter found in the different chapters.

We agree with Mr. Houghton when he asserts that a firm which claims that there is no need for a cost office is the very concern that requires a thorough overhaul, and we feel that the manager of such an undertaking would be well advised carefully to study this

book, after which he will probably radically alter his views. It is open to question whether the author is justified in averring that a large number of managers either profess inability to collect data or have a great dislike to doing so. Certainly it is not the case in most large firms, and the two major wars rendered a system of costing imperative.

It would be but a poor compliment to the writer of a book covering so wide a range to find that there was little to criticise or to inspire suggestions, and any that we make are mostly in the way of drawing attention to the desirability of further information on some of the matters described. We should certainly like to know where Mr. Houghton would place his cost accountant in the staff layout. Would he have him report to the chief accountant or to the works manager ? While he evidently appreciates the value of a good estimating department and indicates that it should be in close liaison with the cost office, we hope he has not in mind that the estimator should be in a subordinate position, for they should be " opposite numbers," each a valuable check on the other ; indeed, we would go further and suggest that regular tabular statements should be made and passed periodically to the general manager, showing, side by side, estimated and actual expenditure. The author would probably agree that often managers after a little while become enthusiastic about the value of cost accounts and ask for more and more detail, resulting in building up too cumbersome a system, but we should like to know how this can be obviated without destroying the welcome enthusiasm. Again, it is most important that the cost of a job should be known as soon as possible after its completion. What does the author consider a reasonable time factor ? It is too much like " flogging a dead horse " for a manager to have to investigate a case of apparent excessive cost of an article weeks and weeks after it has left the factory. We miss a comprehensive bibliography, the author only referring to some of his earlier works on management and organisation.

Workshop Costs and Costing can be recommended alike to the student who has a leaning towards management and to the manager who begins to realise the necessity for a reliable costing system, one that might even show that by closing one of his branches the profits might increase. It might well be studied by the cost accountant to show him the way an engineer approaches the problem. The book is easy to read, is set out in a methodical way, and is illustrated with useful diagrams, charts and forms.

SHORT NOTICES

Select Methods of Metallurgical Analysis. By W. A. Naish, J. E. Clennell and V. S. Kingswood. Second edition, revised. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 75s. —This volume constitutes a substantial revision of the two first-named authors' well-known book on metallurgical analysis, published in 1929. As in the previous edition, preliminary chapters are devoted to Sampling and to Qualitative Analysis. These are succeeded by an account of selected methods for the analysis of the elements, arranged in alphabetical order. The section devoted to each element is headed by a summary giving the metallurgical occurrence of the element (e.g. in minerals and alloys), a source from which the high-purity metal may be obtained to serve as a standard, and a list of the methods of determination which are subsequently described. This chapter occupies a little more than a third of the text. It provides a useful summary of well-established processes and of recently published analytical methods, with full references to the original publications. This part of the book, for which Mr. V. S. Kingswood is solely responsible, should be of great value to advanced students of metallurgical chemistry.

It is, of course, highly desirable that methods of analysis recommended by an author should be those actually tried in his own laboratory, for only thus can the most helpful assessment of the convenience and accuracy of each method be conveyed to the reader. Even in the comparatively restricted field of metallurgical analysis, however, development has been on such specialised lines that a personal acquaintance with current practice in all its aspects has become impossible to achieve by a single individual. Thus, the steps taken by Dr. Naish in the revision of this book are very well advised. In the book in its new form each section dealing with the analysis of a commercial product has been compiled from the contributions of chemists actually engaged in the particular industry or specialised service to which the section refers. This renders the latter part of the book (Chapters 5 to 12) specially trustworthy. In Chapters 5 to 11 are recorded procedures adopted, often after extensive research and comparative trials, in different branches of metallurgical industry. In this way the analysis of a wide range of commercial products is dealt with : e.g. Iron, Steel and Ferro-Alloys ; Iron Ores and Slags ; Impurities in Non-Ferrous Metals ; Non-Ferrous Alloys of all Descriptions ; Refractory Materials ; Coal and Coke. In the section on alloys a careful distinction is drawn between major constituents and impurities ; and lists of the elements encountered are given, together with their approximate amount and the alloy type in which they are found. These chapters also contain references to original papers of recent date. Chapter 12 is a brief composite account of modern physical methods of analysis, with some reference also to microchemical methods of metallurgical analysis, supplemented by useful bibliographies. Spectroscopic technique occupies a good proportion of this chapter, as indeed it should do in view of the increasingly wide application of spectrographic analysis to metallurgical products.

This new edition of " Naish and Clennell " is marked by many improvements and shows clearly that the revision has been effectively carried out.

BOOKS RECEIVED

Les Terrains Perméables. By A. Mayer. Paris : Dunod, 92, Rue Bonaparte, Paris, 6e. Price 940f.

Energy in the Future. By P. C. Putnam. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 90s.

Riementriebe Kettentriebe Kupplungen. Germany : Friedr. Viewig and Son, Burgplatz, 1, Braunschweig. Price 24·50 D.M.

Liants Hydrocarbonés. By M. Duriez and J. Arrambide. Paris : Dunod, 92, Rue Bonaparte, Paris 6e. Price 6300f.

Grosse Ingenieure. By Conrad Matschoss. Germany : J. F. Lehmanns Verlag, Paul-Heyse-Str., 26, München, 15. Price 20 D.M.

The Locomotives of R.E.L. Maunsell. By O. S. Nock. Bristol : Edward Everard, Ltd., Broad Street, Bristol, 1. Price 17s. 6d.

Electronics. By A. T. Starr. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 32s. 6d.

Essentials of Engineering Thermodynamics. By H. J. Stoever. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 36s.

Fundamentals of the Working of Metals. By G. Sachs. London : Pergaman Press, Ltd., 242, Marylebone Road, N.W.1. Price 30s.

Jahrbuch der Hafenbautechnischen Gesellschaft, 1950–51. Germany : Springer-Verlag, Riechpietschufer, 20, Berlin, W.35. Price 60 D.M.

Basic Naval Architecture. By K. C. Barnaby. London : Hutchinson's Scientific and Technical Publications, Stratford Place, W.1. Price 35s.

Industrial Electronic Engineering. By W. L. Davis and H. R. Weed. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 55s.

Intermediate Engineering Drawing. Fourth edition. By A. C. Parkinson. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 10s. 6d.

Industry and Science : A Study of Their Relationship Based on a Survey of Firms in the Greater Manchester Area Carried Out by the Manchester Joint Research Council, 1950–1953. Manchester : Manchester University Press, 316, Oxford Road, Manchester. Price 12s. 6d.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

HISTORY OF ELECTRICAL EQUIPMENT IN NAVAL VESSELS

SIR,—In order to collect all possible information available for a proposed history of electrical engineering in the Royal Navy, may I appeal to readers for any information they may have regarding the early days of electrical equipment in all types of vessels, particularly the period about 1880 ? It is desired to make the survey as comprehensive and authentic as possible, as hitherto the subject seems to have been neglected as a whole.

The Lords Commissioners of the Admiralty have kindly permitted access to naval records, but as I am anxious to cover the trend of electrical development in surface ships generally, both in this country and abroad, I should be very grateful if shipbuilders, shipping companies, and electrical manufacturers, who were responsible for the earlier installations and have information which can be considered of interest on the subject, would communicate with me at the address below.

Any offers of photographs, &c., will be very welcome, but these should not be sent at this stage.

F. RAYNAR-WILSON

1, Prior Park Road,
Bath, Somerset,
March 19th.

British Refrigeration Association

ON Friday last the British Refrigeration Association held its tenth annual luncheon at the Connaught Rooms, Great Queen Street, London, which was attended by over 400 members and their guests, with Mr. R. H. Hemmings in the chair. The loyal toast was honoured and then Lord Mancroft proposed the toast of " The British Refrigeration Association," who referred to the fact that the value of the exports of the refrigeration industry rose to £13,000,000 in 1953. Pointing out that nearly 70 per cent of our food was imported and that it had to be paid for by exports, Lord Mancroft emphasised the need to sell our goods not only at a price the customer was prepared to pay, but also to deliver them when and where they were wanted. Another point, he continued, was the importance of keeping contract dates in a highly competitive market. He felt that British goods had nothing to fear, provided that the quality was maintained and that good maintenance facilities were available. He did not advocate attempting to fight our competitors in the cheap mass-produced market, but rather on our own ground and indicated the opening up of new markets in the Middle and Near East through the increased wealth in those countries derived from oil. The existence of a market was, however, not enough, Lord Mancroft said, and dynamic salesmanship was required. Mr. E. G. Batt, who replied, said that the industry had recovered its position during 1953 following a serious decline in turnover in the previous year, but, he added, competition was strong and there was no room for complacency. Touching upon education, he deplored the lack of technical men and appealed to the industry to nominate more students to the National College of the industry. He then repeated a statement made, earlier in the week, at the Institute of Refrigeration dinner, that the council of the Association had agreed to provide funds for research for the next two years. Mr. Batt was hopeful of a new scheme to overcome the difficulties of purchase tax and also appealed for a more plentiful supply of sheet steel. Mr. N. F. T. Saunders proposed the toast of " The Chairman," and in the course of his reply Mr. R. H. Hemmings paid a tribute to the work of Mr. E. G. Batt, and made a presentation to him on the occasion of his retirement from the post of director and secretary of the Association.

Institution of Mechanical Engineers

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1953

LAST Friday, March 19th, the Council of the Institution of Mechanical Engineers presented its annual report on the work and progress of the Institution during 1953.

The total membership of the Institution in all classes had reached the figure of 41,079 at the end of the year 1953.

Membership of Institution of Mechanical Engineers

	Hon. M.	M.	A.M.	C.	Assoc.	G.	S.	Totals	
Totals at December 31, 1952	31	4,749	16,043	33	923	13,337	4,454		39,570
Elected	3	43	291	1	9	1,358	858		
Reinstated	—	—	2	—	—	3	7		
Transferred	—	155	1,075	—	1	651	—		
Total additions during 1953	3	198	1,368	1	10	2,012	865	+4,457	
Deceased...	—	121	124	—	6	17	5		
Resigned...	—	11	16	—	9	62	91		
Erased	—	7	31	—	7	50	74		
Elections voided	—	—	1	—	—	9	30		
Transferred	—	—	152	1	9	1,057	663		
Lapsed	—	—	—	—	—	92	303		
Total deductions during 1953... ...	—	139	324	1	31	1,287	1,166	−2,948	
Net alterations during 1953	+3	+59	+1,044	—	−21	+725	−301		+1,509
Totals at December 31, 1953	34	4,808	17,087	33	902	14,062	4,153		41,079

Coronation : Loyal Address to the Queen

An illuminated and engrossed Loyal Address was presented to the Queen on the occasion of her Coronation. Her Majesty was later graciously pleased to sign the Royal Patron and Honorary Members' book. The president, Mr. A. Roebuck, was among the guests in Westminster Abbey during the Coronation.

Appointment of Assistant Secretary

The council appointed Mr. K. H. Platt, M.B.E., B.Sc. (member), as assistant secretary as from May 1st.

Sheffield Summer Meeting

The Summer Meeting was held in Sheffield on Wednesday, Thursday and Friday, July 1st, 2nd and 3rd, and 437 members, accompanied by 236 ladies, registered for the meeting. The Lord Mayor of Sheffield, Councillor Oliver S. Holmes, F.C.A., J.P., extended an official welcome at the opening meeting in the Central Hall, Sheffield, on Wednesday, July 1st, and this was followed by a short address by the Master Cutler, Sir Harold West (Companion), to which the president replied. The council wish to place on record their grateful thanks to the many generous hosts, and to the officers and members of the reception and executive committees whose efforts contributed so largely to the success of the Summer Meeting.

Parliamentary Bill

The Parliamentary Bill, which was approved by corporate members at a special general meeting held on October 23, 1953, was presented to Parliament on November 27, 1953, and is now passing through its various stages.

Revision of By-Laws

The submission of revised draft by-laws to corporate members for their consideration has been delayed pending the passage of the Bill which the Institution recently presented to Parliament, which may to a certain extent influence the revision of the by-laws. It is the desire and intention of the council that there should be as little delay as possible in the completion of these by-laws, which would be of advantage to the Institution as a whole.

Specialist Groups

The work of the specialist groups was continued throughout the year, and a high proportion of the general meetings were held in collaboration with one or more of these groups. Many of the papers discussed were initiated by group committees. Eighteen general meetings were arranged in conjunction with groups, as follows :—

Industrial Administration and Engineering Production	5
Steam	3
Hydraulics	3
Applied Mechanics	3
Education	2
Internal Combustion Engine	2

Whole-Day Conferences

Two whole-day conferences took place during the year. On February 13th a Conference on Hydraulic Servo-Mechanisms was held in London, during which six papers were presented for discussion. The chair was taken by Mr. G. A. Wauchope (member), chairman of the Hydraulics Group, and by Mr. F. H. Towler (member), during the various sessions, and 420 members and visitors attended.

On March 6th a Conference on Steam Turbine Research and Development was held in London, during which six papers were presented for discussion. The chair was taken by Mr. P. L. Jones, M.C., B.Sc., Wh.Sc. (vice-president), and by Dr. R. W. Bailey, Wh.Sc. (vice-president), F.R.S., during the various sessions, and the average attendance at the sessions was 100 members and visitors. Both conferences were opened by the president, Sir David Pye, C.B., M.A., Sc.D., F.R.S.

Automobile Division and Group Discussions

In response to members' requests, the council during the year initiated a series of meetings to be known as Automobile Division Discussions and Group Discussions. These meetings are arranged in conjunction with the Automobile Division and the Specialist Groups, and differ from the usual general meeting discussions in that no formal papers are presented and no record of the proceedings is taken. The meetings are intended to provide an opportunity for all members to take part in open discussion on interesting technical subjects. Meetings have usually been held on Wednesday evenings at 6.45 p.m.

A notable feature of these discussions so far held has been the high proportion of those present who have made contributions. The meetings have been held in the informal atmosphere of the lower meeting hall of the House of the Institution in London, and have been deemed very successful.

The following subjects have been discussed during 1953 :—

Automobile Division Discussion, October 27th : "Is There a Demand for a People's Car ?"

Industrial Administration and Engineering Production Group Discussion, November 4th : "The Productivity Report on Inspection in Industry."

Hydraulics Group Discussion, November 25th : "The Relative Importance of High Pump Efficiency as Compared with Other Factors."

Applied Mechanics Group Discussion, December 2nd : "Materials for Pipelines in the Process Industries and Their Fabrication."

Steam Group Discussion, December 17th : "The Rapid Shutting-Down of Large Generating Plant Under Fault Conditions."

The House of the Institution

The council express regret for any inconvenience caused to members visiting headquarters, by the carrying out of improvements to the House of the Institution. It is expected that the improvements in amenities resulting from the alterations will be of considerable benefit, both to members and to the Institution staff. Accommodation in Nos. 2 and 4, Old Queen Street, adjoining the Institution House, has been taken over and converted for use by the staff. In addition, a joint heating scheme with the Institution of Civil Engineers has been completed and is now in satisfactory operation. This scheme has resulted in improved efficiency and economy in heating arrangements, and has provided scope for enlarging meeting hall accommodation.

James Watt International Medal

The 1953 James Watt International Medal was awarded to Sir Harry Ricardo, B.A., LL.D. (honorary member), F.R.S., Great Britain, for his contributions to knowledge of the fundamental principles of internal combustion engines and the application of these principles to design and development. The presentation took place at a general meeting in London on Friday, January 23rd.

James Clayton Fund

The bequest under the will of the late Mr. James Clayton provides for the annual award of a prize, a lecture or lectures, and of fellowships bearing his name. The following particulars relate to the administration of the fund during the year.

Award of the 1952 *James Clayton Prize.*—The will provides that a sum not less than one-quarter of the annual income shall be awarded as a prize to a member, associate member, graduate or student who, in the opinion of the Council, has contributed most in the year to modern mechanical engineering science by way of research, invention or experimental work, or by a treatise or paper on a modern mechanical engineering subject, or by originality in design, or by service to mechanical engineering.

The sum allocated for award by the council for the purpose during 1952 amounted to £1610, and the council decided that the prize be divided into equal moieties and awarded to Harold Hillier, O.B.E. (member), for his contributions to marine engineering, particularly in the field of auxiliary machinery, and to Professor Herbert Walker Swift, M.A., D.Sc. (Eng.) (member), for his contributions to mechanical engineering in the field of education, lubrication and experimental research.

The prizes were presented to the recipients at a general meeting on February 20, 1953, and were accompanied by certificates bearing the Seal of the Institution.

James Clayton Lectures.—A James Clayton Lecture was delivered by Mr. James R. Bright, of the United States.

Awards Under the James Clayton Bequest Fund.—In June, 1953, six new fellowships, four new grants and four extensions of existing fellowships or grants were awarded under the terms of the James Clayton Bequest Fund. One grant was subsequently not taken up. The value of the fellowships and grants was over £4500.

Benevolent Fund

The council wish to draw attention to the work of the Benevolent Fund and do so with the confident hope that members will continue their generous support of this worthy cause. Members who are not already subscribers to the fund are asked to join and in that way help the Committee of Management in the work they undertake for the fund. During 1953 a sum amounting to £7998 was granted to eighty-four cases. As the Institution bears the cost of administering the fund, practically the whole of each subscription received is applied to the allowances and grants. In connection with the latter the Committee of Management have continued to assist with the education of the children of deceased members.

Library and Reading Room

Mr. Alfred R. Stock, F.L.A., retired from the office of librarian in July, 1953, and was succeeded by Mr. Reginald T. Everett, B.E.M. Increasingly heavy use of the Library's service has been made by members throughout the year. The current issues of 400 periodical publications are exhibited in the Reading Room, and this involves the handling by the Library staff of over 11,000 separate issues during the year, all of which have to be recorded and filed. In addition, the records which show that 13,767 books have been lent from the Library do not really give a true picture, as it is conceivable that the issuing of one of these volumes may have necessitated much painstaking research to find the most useful work to fulfil a member's requirements. It is interesting to note that over 2500 new works have been added during 1953, bringing the total stock held to some 53,000 publications.

Members unable to call at headquarters have taken advantage of the Library service by post and telephone, some 6523 letters and almost 3000 telephone inquiries having been dealt with throughout the year.

Eusec Conference on Engineering Education

At the invitation of the Institutions of Civil, of Mechanical, and of Electrical Engineers a conference was held in London between January 12th and 17th to discuss education and training of professional engineers. It was attended by representatives from Canada, from the United States, and from a number of countries in Western Europe. Generally, each country sent three representatives, one concerned with university education, one with industry, and one with the activities of engineering societies in their own country. Papers were presented from each country and were subsequently discussed, setting out methods of giving academic education and practical training for the professional engineer.

Eusec Conference, Paris, September, 1953

The president and the secretary, and the presidents and secretaries of the Institutions of Civil and Electrical Engineers attended the conference, together with representatives of engineering societies in Western Europe and the United States. The report of the Conference on Engineering Education, which had been held in London earlier in the year was received. A wide range of matters of importance to professional engineers was discussed, including abstracting services, exchange of information with kindred societies in the Commonwealth and the United States, and visits abroad of students and lecturers.

Research

Pipe Flanges Research Committee.—Material for the third report of the Pipe Flanges Committee has been collated, and the report is to be presented at a general meeting during 1954.

Birmingham University : Investigation on Hydraulic Lock.—Experimental work has been continued, using pistons of different form in conjunction with a cylinder of uniform bore fitted with pressure tappings at suitable points in its periphery. Close confirmation has been obtained for the results of the previous theoretical analysis, both in regard to the pressure distribution in the interspace between cylinder and piston-lands and to the magnitude of the locking force to be expected under given conditions. It has been established that hydraulic lock, under the conditions considered, is a purely hydrodynamic effect. Thus, in general, an asymmetrical pressure distribution exists in the clearance space between piston and cylinder, with the result that lateral forces are set up which, depending on the form of the clearance space, tend either to produce or to obviate lock. The form of the pressure distribution, under given conditions, and hence the locking force on the piston, may be determined mathematically. The first stage of this investigation is now virtually complete and a report is in preparation.

King's College, London. — Experience gained with the small-scale differential analyser suggests that considerable enlargement would scarcely be justified since the setting up and operation of the machine is rather slow, and the cost of manufacture fairly high and, furthermore, the increased availability of electronic computers has, to some extent, rendered such developments unnecessary. The present machine is being used in connection with the instruction of students and for this purpose proves to be of very considerable value.

Leeds University.—The investigation on the effect of efficient scragging on the elastic limit and fatigue properties of silico-manganese spring steel plates, in both the plain and shot-peened conditions arising out of the investigation on similar plates with normal scragging, has shown that remarkable improvements in both the properties mentioned are obtained in both plain and shot-peened plates. The construction of *S–N* curves with efficiently scragged plates is nearing completion.

Manchester College of Technology.—The following work has been carried out during 1953 :—

(1) An investigation of the properties of materials when subjected to high rates of strain in shear, and the correlation of the data with current cutting tool theory.

The equipment is completed and working well.

(2) An investigation of the life of high-speed steel tools under discontinuous cutting conditions. (This investigation correlates, it is hoped, with the previous investigation on tool wear.)

The work is progressing satisfactorily.

(3) Research on tapping. This work has been considerably delayed by building alterations, &c., but is now starting again with improved equipment.

(4*a*) Investigation of the modes of continuous chip formation under plane strain conditions by a process involving the abrupt stopping of the cut.

(4*b*) To investigate conditions promoting changes in the mode of chip formation.

Equipment for this work is now in operation and good progress is being made.

(5) Measurement of damping vibrations in machine tool and similar beds.

Very substantial progress has been made with this work.

Royal Anthropological Institute.—As reported in 1952, work has been continued upon the origin and history of Britain's earliest copper and bronze tools and weapons. The initial co-ordination of techniques between various workers has been considered, and the first of a series of reports published (*Man*, 1953, No. 150). In this report it is noted that certain implements have been submitted to metallographic examination in addition to the routine work of a spectrographic analysis.

Contribution to the Funds of the Institution from Viscount Weir

It was with great pleasure that the president, Sir David Pye, C.B., M.A., Sc.D., F.R.S., announced at the annual general meeting on March 27th the receipt of a cheque for £10,000 from the Right Hon. The Viscount Weir, P.C., G.C.B., LL.D. (honorary member). Viscount Weir desired that the money should be used or applied in benefiting the work of the Institution in any useful direction or form of activity, according to the discretion of the council. The council subsequently decided to establish a Trust Fund, to be called the "Viscount Weir Fund," which should, as they might from time to time direct, be applied for any one or more of the following purposes :—

(*a*) To award a prize or prizes to be called "The Viscount Weir Prize" or "The Viscount Weir Prizes," for technical contributions submitted by graduates or students or both graduates and students on a subject or subjects to be selected by and on such terms and conditions as may be prescribed by the council from time to time.

(*b*) For charitable purposes of the Students' Aid Fund of the Institution.

(*c*) For charitable purposes of any of the Graduates' Sections of the Institution.

Bequest from Mr. C. W. Bate Crossley

The late Mr. C. W. Bate Crossley, who was a member of the Institution from 1932 to 1941, has bequeathed a sum of money to the Institution. The terms of the bequest are "To provide a scholarship with the Institution of Mechanical Engineers ; the subject of paper might preferably be 'British-Made Machine Tools.'"

Bust in Bronze of James Watt

The council are particularly happy to record the presentation by Mr. G. Nelson Haden, O.B.E. (member of council), of a bust in bronze of James Watt, to be permanently erected in the new James Watt Room.

Joint Overseas Groups

The council are collaborating with the councils of the Institution of Civil Engineers and of the Institution of Electrical Engineers to provide facilities for members in certain territories overseas of the three Institutions to meet together for the purpose of holding meetings at which papers of mutual engineering interest are presented and discussed, to arrange visits to works, and so on.

Colour-Light Signalling on the Southern Region

ON Sunday last a further stage in the scheme for providing colour-light signalling on the Southern Region of British Railways was completed with the putting into service of the installation in the areas of Norwood Junction, Selhurst and East Croydon, on the London Bridge and Victoria to Brighton lines. The first colour-light signalling installation was introduced on the former Southern Railway between Blackfriars and Holborn twenty-eight years ago, and with this new installation there are now 435 track miles, or 124½ route miles, of multiple aspect signalling in operation on the Southern Region.

The new installation forms the third of the four-stage scheme described in our issue of November 17, 1950, and it links the first stage from Bricklayers Arms Junction to Norwood Junction (carried out in 1950) with the second stage from Battersea Park to Selhurst (carried out in 1952) so that continuous colour-light signalling will be in use from Victoria and London Bridge to East Croydon approaches.

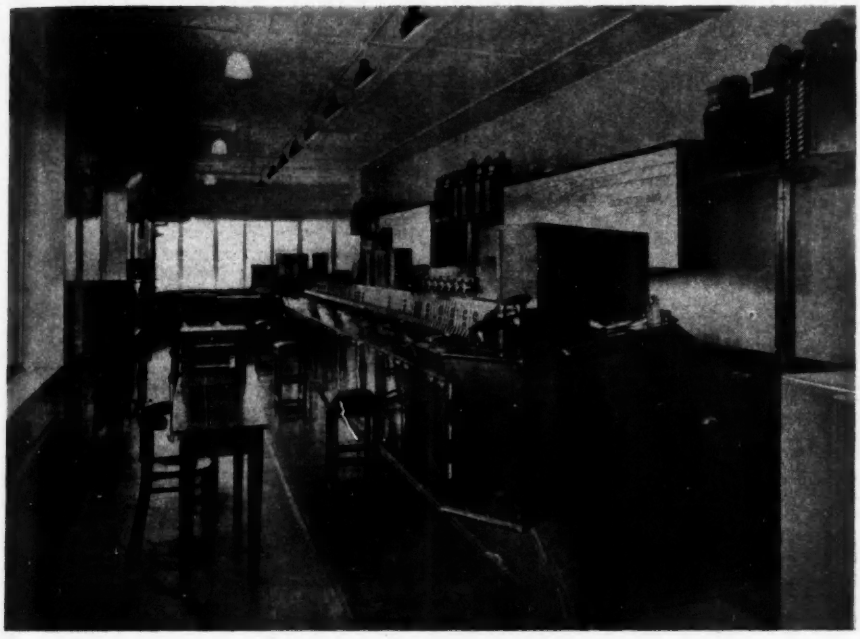
The fourth stage, East Croydon to Coulsdon North, to become effective in 1955, will join up with the present colour-light signalling between Coulsdon North and Brighton.

The present stage includes the provision of two new all-electric signalboxes, one at Norwood Junction containing a 107-lever frame, and the other in the triangle of the Selhurst, Croydon, Norwood lines called "Gloucester Road Junction," and containing a 131-lever frame. This area handles main line traffic from Victoria, London Bridge to Brighton and other South Coast towns, in addition to the very considerable suburban services from both termini to the South London suburbs. The busy junctions of the Gloucester Road area were controlled from four manually operated signalboxes totalling 235 levers and their replacements by the one signalbox will facilitate the efficient control of trains through the area with a minimum of delay.

The new Norwood Junction signalbox replaces two manually operated signalboxes totalling 155 levers. The nature of the layout was not conducive to automatic signals, there being only six in the area, which covers 4¾ route miles and 17¼ track miles. A new all-electric signalbox is to be installed at East Croydon under Stage IV of the scheme and the structure, which has already been built to house part of the final relay room equipment, was brought into use under Stage III, controlling signalling functions operated from the existing manually worked signalbox at East Croydon North. This will facilitate the final conversion under Stage IV, when East Croydon North and South signalboxes will be abolished. Both new signalboxes conform to the familiar S.R. design incorporating the relay room immediately below the signalling floor, the accumulator room, stores room and staff accommodation being in the winged extensions.

Electric power for the signalboxes is supplied from a 3·3kV ring main cable fed from the substation at Waterloo through a group of three 3·3kV, 25MVA, metalclad oil circuit breakers.

In the area there are eighty multiple-aspect, long range signals and twenty-three junction indicators. The signal spacing provides for two-and-a-half minutes' headway for following stopping trains. For the signals, lightweight bridges were designed and erected by the Civil Engineer of the Southern Region and tubular steel straight posts with galleries were designed by contractors to the Signal and Telecommunications Engineer's requirements and erected by railway staff. There are thirty-six solenoid-operated floodlit disc shunting signals.



Signalling Floor at Gloucester Road Junction

Most of the 110-point machines are operated from 120V accumulator batteries at the new signalboxes, the batteries being trickle charged by rectifiers; there are also standby rectifiers at these boxes for direct point operation if necessary. Through telephones connected to separate circuits which are provided at all automatic and most controlled signals, train crews have direct communication with the signalbox concerned.

The system includes 175 condenser fed track circuits, single and double rail, incorporating 114 impedance bonds. Track relays are, so far as possible, located in the signalbox relay rooms, local controller rooms, or in the apparatus cases of automatic signal locations.

Almost throughout the cable route surface concrete troughing is used. In the multi-core v.i.r. lead sheathed, protected and served signalling cables the numbers of conductors vary from ten to forty. The installation includes approximately 750 core miles of signalling cable, 80 pair miles of dry-core lead sheathed and s.w. armoured telephone cable, and 7 miles of oil impregnated paper insulated lead sheathed s.w. armoured twin feeder cables for 480V and 110V distribution.

The lever frames follow S.R. design and are to have miniature individual levers with all-electric interlocking, each lever being fitted with two lock magnets, one for interlocking purposes and the other for track and indication locking. All signal levers are fitted with back or normal indication locks, but front or normal selection locks are not provided. Normal and reverse track locks are fitted to each point lever. Behind each signal lever is repeated in miniature lights all aspects of the signal it controls, that is, red, one or two yellows, or green.

Running and shunt signals also have an "F" light indication behind the lever which, when illuminated, tells the signalman that the signal can be cleared by reversing the lever. Behind each point lever is an illuminated "N" or "R," indicating the position of the points it controls. Behind the lever frame is a large illuminated diagram of the area controlled by the signalbox, showing all signals, points and track circuits, together with their identification numbers and letters.

Magazine train describers are provided between all signalboxes and with them signalmen, by pressing an appropriate button, advise adjacent signalboxes of the next train, its class and destination. The receiving instrument indicates the first, second and third trains, the indication automatically stepping up one as each first train is cancelled on passing the signalbox. There are sixteen of these sending and sixteen receiving instruments, together with associated equipment. Each signalbox is in telephonic communication with signals, adjacent signalboxes and "traffic control," telephone positions being duplicated as necessary so that the booking lad can also deal with calls.

The relay rooms house main transformers, fuses, rectifiers and all the control apparatus on which depends the safe operation of the system. The main signalling supply at each signalbox is 480V into the relay room from the mechanical and electrical engineers' portion of the signalbox. Local distribution is at 110V but all automatic signal and other major locations are fed at 480V. The controlling relays, of which there are 600 in the various rooms, are on steel racks conveniently placed for observation, testing and changing. The fuse and cable terminal panels, also of steel, are up to 24ft long, and each fuse panel carries 500 to 700 fuses.

This signalling changeover was carried out within a six and a half hours' possession of all lines throughout the whole area affected. It entailed the abolition of over 160 signal arms and fittings and a number of signal dolls and posts. In the course of the work 110 sets of points were disconnected from the redundant signalboxes and reconnected to the new electric point machines previously installed and tested. The whole of this signalling installation has been designed and carried out by the Signal and Telecommunications Engineer's Department.

Technical Report

The Calculation of Heat Transfer by Radiation. Fire Research Special Report No. II. The Department of Scientific and Industrial Research, Charles House, Regent Street, London. Price by post 1s. 7½d.—Whilst the fundamental laws of thermal radiation are to be found in textbooks, the engineer concerned with practical problems in the heating of buildings, furnace design, illumination engineering and similar fields needs a knowledge of the actual methods by which radiative heat transfer may be calculated. This report presents the information which is available together with tables of functions for use in making the calculations required in solving radiation problems.

It describes the use of the configuration factor, the ratio of the radiation intensity at the receiving element to that near to the radiator, and the considerations which must be taken into account in determining the factor in particular circumstances. A section on heat transfer considers transfer between extended surfaces and between reflecting surfaces of various configurations.

Kemano Hydro-Electric Development and Associated Kitimat Aluminium-Reduction Works*

By F. L. LAWTON, B.A.Sc.†

This paper deals with the electrical aspects of the Nechako-Kemano-Kitimat hydro-electric power development and the associated aluminium-reduction works in the Province of British Columbia, Canada. It discusses many elements of the power development wherein new engineering ground has been broken. The unusually heavy electrical loading of the 300kV transmission system is treated at some length, as well as the mechanical loading. In addition, the plant power supply features of what will ultimately be the largest aluminium-reduction works in the world, at Kitimat, are discussed. Comparative information is given on the characteristics of the impulse turbines, generators, main step-up and step-down transformer banks, and 300kV power cables, derived from the manufacturers' tenders.

THE Nechako-Kemano-Kitimat hydro-electric development and the associated aluminium-reduction plant‡ are sited in the Coast Range country of British Columbia, with water access about 500 miles from Vancouver and 180 miles from Prince Rupert. The Kenney rockfill dam, which is the third highest of its type in the world and is located some 16 miles downstream from Natalkuz Lake on the Nechako River, permits impounding the run-off of the Eutsuk-Tetachuck-Euchu and Tahtsa-Whitesail-Ootsa-Natalkuz drainage systems at full reservoir level at an altitude of 2800ft above sea level. This enables the flow to be reversed westward through Tahtsa River and Lake, and diverted through tunnels piercing the Coast Range, instead of pursuing its normal course through the Nechako River to the Fraser River and thence to the Pacific at Vancouver. From the power tunnels the flow passes through pressure conduits to the impulse turbines and thence to the Kemano River.

The storage reservoir has been filling since October 8, 1952, when the diversion tunnel at Kenney dam was closed, the dam itself being completed before the end of the year. The Kenney dam is a storage and diversion dam only. Any excess of influx to the reservoir will be discharged at a spillway with a capacity of 30,000 cubic feet per second at Skins Lake and thence through the Cheslatta Lake drainage to the Nechako below the Kenney dam.

With the storage reservoir created by Kenney dam providing 873×10^9 cubic feet capacity, and an average total run-off of 7470 cubic feet per second, it will be possible to utilize a regulated flow of 6920 cubic feet per second through the turbines. The annual average reservoir level will be at an altitude of 2795ft, overall variation being about 6·5ft under average conditions, and about 17ft under minimum water conditions. Since the turbines are located with a nozzle setting at 210ft above sea level, the gross head on the turbines under average reservoir level is 2585ft. From the head and regulated flow figures it is estimated that 1,718,000 h.p. can be generated.

There will be two power tunnels of 25ft equivalent diameter, spaced 300ft apart, running 10·1 miles through the Coast Range between the intake structure at the west end of Tahtsa Lake to the base of the surge chamber. Only one of these is being excavated at present, with some 55 per cent of its length driven. Although each tunnel will normally convey 3500 cubic feet per second, it is designed to handle a maximum flow of about 4500 cubic feet per second.

The spherical valve controlling the flow to each turbine will be double-seated, with a cast steel body ; the body seat-rings will be movable, and the operating controls so arranged that the upstream seal is normally disengaged. Designed to pass a maximum flow of 555 cubic feet per second under normal operating conditions, the 51in diameter valves will be under a maximum velocity of 39·2 feet per second ; the maximum velocity in the 5ft branch pipes will be about 23·6ft per second.

Turbines and Generators

At this point it will be helpful to outline the thinking which governed the choice of sixteen units for the ultimate development of the Kemano power plant. As previously noted, a regulated flow of 6920 cubic feet per second under a net head of about 2500ft will allow the generation of 1,718,000 h.p. However, it will be possible to generate 2,240,000 h.p. over considerable periods of time. For the particular head, about the largest four-nozzle vertical single-runner impulse turbines it is at the moment feasible to build, with optimum characteristics, are units with a rating of 140,000 h.p. and an anticipated maximum output of 150,000 h.p. each. This requires a total of sixteen units operating at rated output to generate 2,240,000 h.p. The turbine rating also corresponds very well to generator possibilities, from the aspect of proven design features and transport limitations.

Table I—*Turbine Data*

Turbine No.	1	2	3
Manufacturer	A	B	C
Guaranteed max. output, h.p.	140,000	140,000	140,000
Expected max. output, h.p.	147,000	150,000	158,000
Expected max. discharge, cubic feet per second	575	590	625
Guaranteed max. efficiency, per cent	89·5	90·0	89·5
Expected max. efficiency, per cent	92·5	92·0	91·5
Expected efficiency at F.L., per cent	90·2	89·5	88·8
Expected efficiency at ¾ L., per cent	92·5	92·0	91·5
Expected efficiency at ½ L., per cent	91·0	90·5	90·1
Shaft weight, lb	48,000	57,000	47,000
Runner weight, lb	72,000	89,900	48,000
Runner diameter, inches	160	162	162
Total turbine weight, lb	565,000	676,000	708,000

The initial three units are each built by different manufacturers, pertinent tender data being presented in comparable form in Table I.

The turbine governors are actuated from permanent-magnet generators. Each turbine is protected against overspeed and loss of governor-oil pressure, and is equipped with bearing temperature, oil-flow and water flow alarm devices.

The hydraulics of the power tunnel and pressure conduit system, as reflected in pressure surges, necessitate the use of a minimum turbine nozzle needle opening time of about 30 seconds. Initially, operating requirements involve picking up two 100MW blocks of load, one at a time, and carrying this load on a minimum of two generating units. This requirement has been met by the provision of a preset needle opening solenoid actuated from the control room. When ready to pick up the load, the control room operator will press a unit push-button ; as the needles open and the frequency rises, the governor cuts the deflectors into the jets, reducing the power input to the turbine and halting the frequency rise. When the needles have opened to the preset position, at about 75 per cent of full load, a signal lamp adjacent to the push-button and the needle limit indicator on the instrument board will indicate this state. At this point the Kitimat operator will be instructed to pick up the reduction-plant load. The frequency drop following pick-up will cause the governor to withdraw the deflectors and the unit to generate the demanded output. Operation of the deflectors has no effect on the flow of water through the pressure conduit system and can be quickly effected, the time being about three seconds. Loss of load will not occasion excessive frequencies, as the deflectors will quickly deflect the power jets from the turbine buckets. This will permit closure of the needles in the relatively long time of approximately one minute, as dictated by the hydraulic properties of the tunnel and pressure conduit system.

The vertical three-phase 60 c/s, twenty-two pole, 327 r.p.m., 13·8kV, 0·8 power factor generators are rated at 106MVA at 60 deg. Cent. temperature rise or 122MVA at 80 deg. Cent., and are designed for 610 r.p.m. overspeed. The generators are equipped with direct-connected main and pilot exciters, with the voltage regulators actuating motor-operated rheostats in the main exciter field circuits. Thrust and upper guide bearings are located above the rotor and a lower guide bearing below it.

The generator specifications require that six phase leads be brought out, that the stator winding be suitable for the use of split phase protection and that the ratio between the field discharge resistance and the field resistance be at least 8 : 1.

All generators are furnished with the usual temperature-detector elements embedded in the stator windings, in the bearings and in the cooling air. Flow alarms are provided in the cooling water lines for the air coolers and for the bearings, and in the bearing oil lines. The generators may be operated with the stator winding neutral either solidly earthed or earthed through a loaded distribution transformer. Three different manufacturers are each building one of the three generators to be initially installed. Comparable tender data for the three designs are given in Table II.

Table II—*Generator Data*

Generator No.	1	2	3
Manufacturer	A	B	C
Output, MVA	106	106	106
Power factor	0·8	0·8	0·8
Field current, amp	1,080	710	1,060
Guaranteed efficiency, F.L., per cent	97·3	97·3	97·45
Guaranteed efficiency, ¾ L., per cent	96·8	96·8	96·95
Guaranteed efficiency, ½ L., per cent (All at 0·8 power factor)	95·3	96·0	95·90
Short-circuit ratio	1·0	1·0	1·0
Rotor construction	Flutes dovetailed to shaft and laminated ring carrying poles	Discs shrunk on shaft carrying poles	Rolled plates shrunk on shaft carrying poles
Rotor total weight, lb	640,000	658,000	830,000
Rotor diameter, inches	174	206	194
Rotor iron length, inches	117	90	100
Generator total weight, lb	1,140,000	1,154,000	1,420,000
Generator inertia, lb per square foot	16,400,000	23,800,000	23,700,000
Reactance, per cent :			
X_d	113·2	106·0	105·0
X'_d	28·6	25·0	30·0
X''_d	20·2	18·0	21·0
X_2	24·4	21·5	24·5
X_0	15·0	11·0	15·0
X''_q/X''_d	1·5	1·4	—
Number of parallels in stator	6	2	2
Number of turns in stator coil	3	1	1
Type of stator coil	Whole coils	Half coils	Half coils
Total volume of cooling water, gallons per minute	1,560	1,117	900

Transformers and Switchgear

The step-up transformers consist of double-primary banks of three single-phase units, each with a nominal rating of 71MVA, or 213MVA per bank. These forced oil, water cooled transformers are equipped with two 100 per cent capacity coolers, operation of both coolers boosting the capacity as shown in Table III, in which the tendered characteristics of the two makes of transformer purchased for the initial stage of development are compared. However, the two types are physically and electrically interchangeable.

The transformers have no ratio adjusters. Connected delta-delta-star, the voltage ratings are 13·2/13·2/301·4kV. Each primary winding can carry its full rated load independently of the

* Institution of Electrical Engineers, London, March 25th. Abstracts.

† Aluminium Laboratories, Ltd., Canada.

‡ Lawton, F. L., and Kendrick, J. S. : "Nechako-Kemano-Kitimat Hydro-Electric Power Development and Aluminium-Reduction Plant," *The Engineering Journal*, 1952, 35, page 915.

[A description of the scheme with particular reference to the civil engineering work and the transmission line, appeared in THE ENGINEER, May 29 and June 5, 1953.—Ed. THE E.]

other. The h.v. windings are built with an impulse insulation level of 1050kV, graded to 15kV at the solidly earthed neutral.

Transport limitations fixed a shipping weight of 150,000 lb, which dictated the choice of single phase units. In order to limit the length of the underground power house chamber to that fixed by the generating units, the transformers, which are installed underground, had to be of the double-primary type. This choice results in a slight additional cost for bus connections between generators and transformer primary windings and a 2 per cent increase in the transformer cost. However, this is more than offset by a reduction from 2000MVA to 900MVA in l.v. faults, with consequent reductions in busbar, insulation and disconnect-switch electric strength requirements ; in circuit breaker mechanical strength and rupturing capacity ; and, finally, in the extent of the damage accompanying a fault.

TABLE III—*Kemano Transformer Data*

	Manufacturer A	Manufacturer B
One cooler operating :		
Capacity, MVA	71	71
Temperature rise, deg. Cent.	55	55
Cooling water, gallons per minute	170	220
Two coolers operating :		
Capacity, MVA	95	93
Temperature rise, deg. Cent.	62	62
Cooling water, gallons per minute	266	440
Reactance, l.v./h.v., per cent	10·5	10·7
Exciting current, per cent	1·75	1·00
Shipping dimensions :		
Length, inches	204	214
Width, inches	128	116
Height, inches	186	170
No-load loss, kW	156	90
Load loss, kW	395	375
Guaranteed efficiency (1·0 p.f.) :		
Full load, 71 MVA, per cent	99·22	99·35
Three-quarter load, per cent	99·29	99·43
Half load, per cent	99·28	99·47
Oil, gallons	7,220	6,380
Weight of oil, lb	62,000	55,000
Weight of core and coils, lb	116,000	122,000
Weight of tank and fittings, lb	50,000	58,000
Total weight, lb	228,000	235,000

Busbar connections between the generators and transformer primary windings are designed for 6kA capacity, and consists of 7in double aluminium channel, mostly with welded joints.

The generator circuit breakers were somewhat of a problem, since the current capacity had to be at least 5·5kA ; although in the initial installation only three circuit breakers are necessary, to secure them with the requisite capacity would have entailed development charges and high costs, with possible delays and difficulties. The solution adopted involves the use of two standard 15kV, 4kA, 1500MVA, air-blast circuit breakers operated as a single electric and pneumatic unit. One of each of the six poles in the combination is used in each of the six phase leads from the generator, the phase parallels being connected on the transformer side of the circuit breaker. This solution provides an effective capacity of 8kA, at an economic cost. In addition, the use of an air-blast type eliminates the oil fire hazard.

Low-voltage disconnect switches are designed for a capacity of 6kA.

HIGH-VOLTAGE CABLES

The location of the step-up transformers in the underground generating station necessitates the output of the transformers being transmitted to the 300kV switching station through h.v. power cables. The output of each step-up bank is being carried by three paper-insulated, oil filled cables per circuit, with a current-carrying capacity of at least 550A. These cable circuits are approximately 2000ft long with a maximum difference in elevation of 75ft. The cables may be described as being of the Pirelli type, with the oil in the central duct under the moderate pressure of 60 lb per square inch maximum.

TABLE IV—*High-Voltage Cable Data*

	Manufacturer A	Manufacturer B
Conductor material	Aluminium	Copper
Conductor shape	Segments	Circular strands
Conductor, number of strands	12	66
Conductor area, circular mils	1,113,000	515,000
Conductor outside diameter, inches	1·09	1·17
Paper insulation thickness, inches	1·08	0·95
Sheath material	Aluminium	Lead
Sheath thickness, inches	0·170	0·115
External reinforcing	Not used	Helical bronze strip
Weight of cable, lb per foot	8·75	13

Two manufacturers are each supplying a cable circuit for the initial stage, comparative data being given by Table IV.

These cables, with their joints and terminals, are designed to meet the same impulse specification as the transformers, namely, 1050kV with a 1·5/40 microsec impulse.

The cables are to be installed in a special cable tunnel, divided into two sections by a vertical wall. Two cable circuits, carrying the output of four generating units, will be carried in each section on insulated supports, with 5ft vertical distance between circuits and 1ft horizontal spacing between cables of the same circuit. The cable sheaths will be earthed at the midpoint only, to eliminate sheath loss.

AUXILIARY POWER SUPPLY

At Kemano, economic design dictates the use of cooling water pumped from the tail-races. Hence the auxiliary power supply at 550V must possess a high degree of reliability. To meet this in the initial stage of development, two three phase, 2·5MVA, water cooled transformers are being installed, either of which can carry the load alone. The No. 1 auxiliary transformer, can be supplied from generators Nos. 2 or 3 directly, or from generator No. 1 through the transformer bank. No. 2 auxiliary transformer can be fed from generator No. 2 directly, or from generators Nos. 1 or 3 through the transformer bank. The various motor-operated switches or isolators for the several sources are so interlocked that generators or step-up transformer banks cannot be paralleled through them. The auxiliary transformers have two separate 550V windings and the largest feasible reactance, in order to limit fault currents to a maximum of 25kA. This permits safe usage of moulded-case circuit breakers on the 550V system, and eliminates the necessity of cascading 550V circuit breakers. One winding in each transformer feeds half of one station-service switchboard and the other winding feeds the other switchboard. All essential load centres can be supplied from either service switchboard and are automatically switched from one source to the other in the event of trouble on the source in use. The field cubicles, where the cooling water pump motors are located, are also supplied from either board.

Careful attention has been given to the auxiliaries of equipment, such as the transformers and 300kV circuit breakers, which serve two generating units. Each of the two coolers on a step-up transformer bank is supplied with cooling water from a separate header. Likewise, the two oil pumps are fed from different field cubicles.

RELAY PROTECTION

Generator Protection.—Generator stator winding protection consists of a differential scheme and a split phase scheme. The differential scheme comprises percentage-type instantaneous balanced-beam relays with restraining and operating windings energised from 6000/5A current transformers on the neutral leads and two 3000/2·5A current transformers on the two phase leads. The split phase scheme involves a double-primary 500/500/5A current transformer located between the generator circuit breaker and its switch so that both windings will always be at the same potential, and so that it overlaps the transformer differential zone. A primary unbalance of 50A or 1 per cent, should operate the high-speed induction-type relays with a time delay of about three cycles. An instantaneous balanced-beam over-current relay in the neutral of the standby current transformers or supplied from a current transformer in the secondary of the earthing transformer will provide fast sensitive protection against faults to earth on the busbar, the l.v. winding of the step-up transformer or the h.v. winding of the station service transformer. The standby protection is furnished by voltage-restraint over-current relays.

This protection operates one of two trip relays, which trip the generator, field and exciter field circuit breakers and the governor shut down solenoid. At 15 per cent normal speed the generator brakes are applied automatically.

A field failure relay, actuated from the field shunt and set for 85 per cent of field current at normal no-load voltage, trips the generator circuit breaker only. The field earth detector, which is an over-current relay in a source applying 110V at 60 c/s between the field circuit and earth, actuates an annunciator signal. This affords protection on the entire generator d.c. and main exciter armature circuits.

Both a.c. and d.c. over-voltage protection is provided. The former operates a contactor, inserting resistance into the main exciter field, as well as actuating the motor-operated rheostat in the "lower voltage" direction. This overrides the voltage regulator, so that loss of potential on the regulator cannot result in over-excitation. The d.c. over-voltage protection inserts resistance into the pilot exciter field.

The generator thrust bearing is protected by two temperature relays : one annunciates only ; the other, at a higher temperature, actuates the trip relay and, at 50 per cent speed, applies the brakes continuously. This arises from the high speed and large inertia of some 25×10^6 lb per square foot, since the generator must be brought to rest as quickly as possible in the event of a thrust-bearing failure, in order to minimise damage. Reduction of governor oil pressure results in a signal and then in the operation of a trip relay before the pressure drops too low to actuate the turbine-nozzle needles.

Transformer Protection.—The transformer bank differential protection utilises current transformers on the l.v. side with a ratio matching that of the main bank, with both h.v. and l.v. current transformers having a saturation characteristic such that the knee of the curve is at 230V, with a magnetising current of 0·1A. The relays are of the differentially-connected, low-energy induction type, with instantaneous trip attachments. An earth relay is energised from a current transformer in the transformer bank neutral connection.

Other Protection Features.—A differential scheme also covers the 300kV power cables by means of through type current transformers around the cable immediately below each termination, using high-speed induction relays. This scheme is intended primarily to simplify the operator's inspection and for guidance in the event of the transformer-zone protection operating, since the time required to inspect all transformers, the cables and both cable terminations, is substantial. If both zones operate, thus indicating a cable fault, the circuit will be out of action for some time. In the initial stage, if the No. 1—2 step-up transformer bank were involved, generator No. 2 would be switched at once to the No. 3—4 bank. If the transformer bank differential operates, a faulty transformer can be changed in about three hours.

All transformers are provided with Canadian-type gas-detector relays having a gas accumulation annunciating element for detection of incipient faults and a pressure trip element for more serious faults. The transformer protection schemes operate either of two trip relays, which actuate the h.v. circuit breaker, the two generator circuit breakers and the exciter field switches.

TABLE V—*Arrangement of Protective Relays*

Generator		Transformer	
Trip relay A	Trip relay B	Trip relay A	Trip relay B
Split phase L.V. neutral Overspeed	Generator differential Standby protection Thrust-bearing temperature Governor low oil pressure	Cable differential H.V. neutral Gas detector Line over-current Station-service gas detector Master earth	Transformer differential Line h.v. earth Station-service over-current Remote trip

Table V indicates the distribution between trip relays of the several protection schemes, the objective being to provide some basic protection for each major item of equipment on each trip relay.

The transmission system relay protection, in the initial stage, comprises phase and earth induction over-current relays, with a total earth-current relay. However, provision has

been made for the installation of phase-comparison-type relaying if found desirable.

Metering and Control

Metering.—For each generator, the three phase currents, the real and reactive power, turbine needle opening and needle limit, the field current, the pilot exciter voltage and the frequency require measurement. The current in the h.v. winding of each transformer is indicated to show the total load on the transformer bank and the 300kV cables. The generator output is

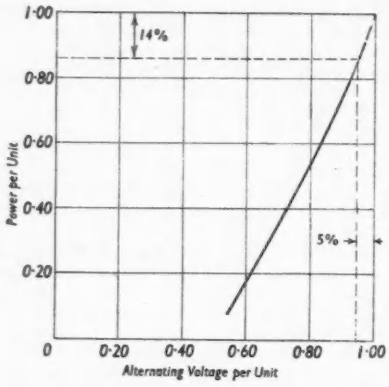


Fig. 1—Variation of Potline Load with Alternating Voltage

summated, indicated and recorded. High-speed multi-point instruments will record the temperature indicated by two embedded thermo-couples in each generator stator winding, and the winding temperature for each transformer will be recorded on similar instruments.

Control.—The control room occupies space in the service area similar to that occupied by the transformers in the remainder of the station, i.e. the width is fixed by the length of the transformer vaults and the length by that of the service bay.

One control feature is worth noting. Aluminium-reduction cell lines or series, commonly termed "potrooms" in North America, are normally supplied by mercury-arc rectifiers. These are quite sensitive to voltage variations but insensitive to frequency fluctuations. Fig. 1 illustrates this characteristic, the curve being a

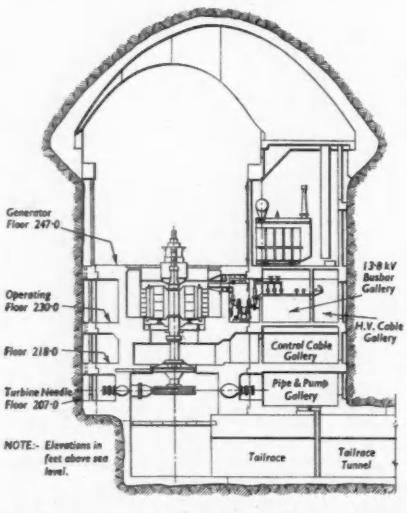


Fig. 2—Cross-section of Kemano Power Station

plot from a test made on a potline in operation. It is planned to telemeter the voltage on the Kitimat high-voltage busbar to the control room in the generating station. During initial stages of development, the control room operator will be able to maintain the Kitimat voltage at a desired level. Before load pick-up, the voltage can be raised by an amount equal to the expected drop on load application.

During later stages of development, the load from a single potroom will be a less significant percentage of generation and such expedients will be unnecessary, except perhaps in the unlikely event of a total interruption.

Generating Station Layout

The sixteen generating units of the Kemano generating station will be housed in a chamber excavated from the solid rock of the mountain mass, located about 1400ft in from the face of the mountain, this chamber ultimately being 1135ft long, 81ft wide and 134ft high.

Fig. 2 is a section through the generating station showing the turbine and the runner removal pit and staging; the generator, associated circuit breaker, l.v. busbar gallery; and the control cable, the pipe and the h.v. cable galleries. It will be observed that the removal of a turbine runner will be effected by lowering the runner to a car on tracks on the staging at the level of the turbine runner removal pit, and moving the car with the runner back to the removal pit without in any way disturbing the shaft, the bearing or the generator. Unit spacing at 60ft centres was fixed by conditions at the turbine needle floor level.

On the operating floor, the passageway under the busbar gallery provides access to the only operating position at each unit. At this location are grouped together the governor cabinet, the generator brake controls and the field cubicle structure which contains the generator and exciter fields circuit breakers, the motor-operated rheostat and contactors, the pilot exciter field rheostat, the a.c. and d.c. distribution panels for the unit, the control station for the cooling water pump for each unit and the generator and turbine bearing temperature indicators, as well as the unit bay lighting panel.

Step-up Transformers.—On the generator and transformer floor the available space accommodates two transformers between each pair of generating units, at 60ft centres—a consideration which influenced the choice of double-primary step-up transformer banks.

Much thought was given to two basic considerations relative to the step-up transformers, namely, the limitation of damage in the event of major trouble on a transformer and the rapid replacement of a damaged transformer.

The first consideration was overcome by the provision of a tripartite pit capable of holding the entire 7000-gallon oil content of a transformer between the deep floor beams. A 12in diameter drain from each element of the pit leads downward directly to the nearest tailrace. The vault fronts will be covered by fire doors; roof hatches with very light, free-resting metal covers provide relief to the plenum chamber above the vaults; and an extensive spray-nozzle system with four automatic temperature sensitive devices completes the fire-protection features.

The second consideration was predicated on the replacement of a faulty transformer in not more than three hours. The heat exchangers are moved with the transformers, thus permitting the use of only four dresser couplings for pipe connections. The installation being independent of weather conditions, all auxiliary leads for oil pump motors, indicators and alarms are effected by plug and socket connections with flexible armoured cable. The four l.v. connections require the maximum time, but at least three men can work simultaneously on these. The transformer will be rolled forward out of its vault, picked up by one crane, and the spare unit put into place, using the second crane if necessary. These cranes are each capable of lifting 225 tons.

The installation of the main transformer banks underground is not unusual, such a procedure having been followed in many European underground generating stations, where the high voltage rating runs up to 400kV.

Ventilation.—An important problem in a sound design of an underground generating station is adequate ventilation. At Kemano, one-half of the station will require 76,000 cubic feet per minute of air, drawn in through the main access tunnel. The incoming air is delivered to the control cable gallery (Fig. 2), whence it is distributed to each unit at the level of the turbine bearing floor. It then passes through floor gratings to the operating floor and thence to the main floor. Some is taken off at each unit on the operating floor to the h.v. cable gallery, whence it discharges through the h.v. cable tunnel. From the main floor most of the air is drawn through the transformer vaults to the plenum chamber and discharged through the ventilation tunnel. Part passes down behind the upstream wall to the turbine floor and pipe gallery, and through floor gratings, discharging through the tail-race tunnel.

H.V. Switching.—The h.v. circuit breakers are of the air-blast type, with an interrupting capacity of 6000MVA on a symmetrical basis at 301kV,

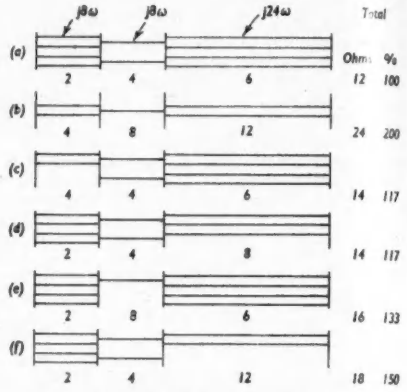


Fig. 3—Variation in Transmission-Line Reactance with Various Line Elements Out of Service

with a rate of rise of recovery voltage of 1850V per microsec. Calculations show that even with all transmission lines disconnected from the busbar, in the ultimate development the rate of rise of recovery voltage will be about 1200V per microsec. With this rate of rise the interrupting capacity is 7000MVA symmetrical at 301kV. The calculated duty is 6000MVA for a line-to-earth fault between the circuit breaker and the h.v. cable termination. The circuit breakers are built for a current-carrying capacity of 800A and an impulse level of 1050kV. The opening time is five cycles and the closing time is six cycles. Opening or closing imposes a current drain of 3A on the storage battery.

The unit h.v. isolating switches are quite standard, in contrast to the line isolators. The latter have a current rating of 1·6kA and are

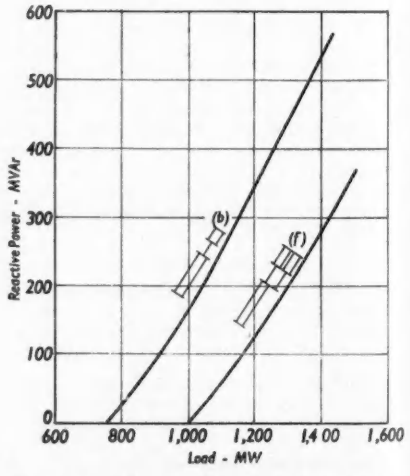


Fig. 4—Reactive-Power Requirements at Kitimat for Acceptable Voltage Conditions

equipped with interrupters in parallel with the main blade to give an interrupting capacity of 90A when breaking line-charging current at 300kV, or a load current of 800A with 60kV across the isolator, several times, before serious contact erosion develops. It is expected that it will be possible to switch the transmission lines without circuit breakers. Should this prove to be feasible, and if transmission line faults are as low as anticipated with the line design and foreseen isoceraunic level, line circuit breakers

will not be installed, although provision is made for them.

Transmission

From the power plant the first 10 miles of the transmission system will comprise two double circuit tower lines, gradually climbing to about 1000ft in altitude, at which point they feed into a switching station with motor-operated selector/isolator switches. The outgoing lines will consist of two single circuit tower lines which traverse a pass with a maximum altitude of about 5300ft for a distance of 10·6 miles. They then descend to another switching station, at an altitude of 500ft, from which two double circuit tower lines will run the remaining distance to the terminal station at the Kitimat aluminium-reduction plant. In this stretch of the line about 3 miles will run between 2000ft and 3000ft above sea level.

Designing for the transmission of 1,670,000 h.p. firm delivery at Kitimat through relatively narrow valleys, having regard to potential snow and rock slides at some points, and across a narrow mountain pass with a maximum altitude of some 5300ft, is a difficult problem. The snow may lie 20ft or more deep during the winter months, and icing conditions may be very severe, with a short construction season. Moreover, the transmission lines must provide absolutely reliable service, because the aluminium reduction process is a continuous one.

[Here the author discussed the design problems imposed by the terrain.]

Transmission-Line Details and Limits.—Many of the significant transmission-line details are summarised in Table VI. It may be noted that the conductor, fittings, clamps and other components were all subjected to design proof tests, so that all components would develop the maximum strength of the insulator strings.

One of the two single-circuit transmission lines across Kildala Pass will be built with steel towers of generally conventional design. The suspension and light-angle towers will weigh about 33 tons each ; the heavy angle and the strain types will be substantially heavier, depending on height. The other single-circuit transmission line across Kildala Pass will be built with aluminium towers, using a design of which a prototype has been successfully built and thoroughly tested. This design is a braced " H "-frame type of tower with five thin-walled aluminium tubes of about 38in diameter and a box girder cross arm. These towers will weigh substantially less than the corresponding steel towers and are expected to show substantial economies in transportation, erection and maintenance.

Because the electrical loading of the transmission system as outlined represents a far heavier load than has hitherto been transmitted 50 miles over such a transmission system, and because the reliability of service must be high, the whole system was set up on a network analyser, account being taken of the necessary characteristics of the generating equipment, the step-up and step-down transformers, the transmission circuits and the mercury-arc power-conversion equipment at the load.

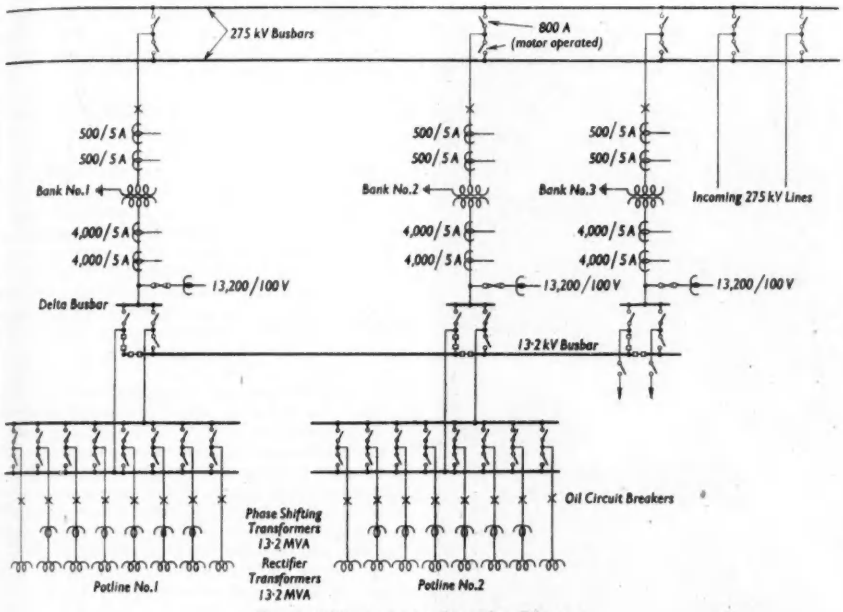


Fig. 5—Kitimat Initial One-Line Diagram

Table VI—*Transmission-Line Data*

	Double circuit	Single circuit
Total initial length, miles	1 at 39	2 at 10
Total ultimate length, miles	2 at 39	2 at 10
Conductor name	" Falcon "	" Emu "
Ultimate strength, lb	55,000	136,000
Area, circular mils	1,590,000	3,360,000
Steel strands	19	37
Aluminium strands	54	108
Overall diameter, inches	1·55	2·30
Weight, lb/ft	2·03	4·76
Number of armour rods	12	16
Armour rod maximum diameter, inches	0·508	0·522
Diameter over armour rods at clamp, inches	2·6	3·3
Suspension-clamp design strength, lb	25,000	75,000
Test strength, lb	>37,000	>110,000
Test slip load, lb	10,000	30,000
Design slip load, lb	3,000	10,000
Number of suspension units per string	16	18
Number of dead-end units per string	18	20
Insulator ultimate strength, lb	25,000	25,000
Number of strings :		
Suspension, normal	1	3
Dead end	3	6
Reactance, ohms/mile at 60 c/s	0·734	0·771
Resistance, ohms/mile at 60 c/s	0·0684	0·0326
Susceptance, micromhos/mile at 60 c/s	5·78	5·49

Fig. 3 (*a*) indicates the normal reactance of the transmission system, whilst (*b*)-(*f*) show various possible conditions arising with different parts of the system out of service. The reason for the provision of the two switching stations is that they reduce the line reactance from 200 per cent of normal with (*b*) to 150 per cent with (*f*). The (*b*) situation can be offset by a source of reactive power installed at Kitimat. Fig. 4 indicates the corrective capacity required at the load for the (*b*) and (*f*) conditions. The transmission of 1200MW requires 350MVAr under the (*b*) condition, but only 130MVAr under the (*f*) condition.

Normal operation of the transmission system when fully loaded in the ultimate development will utilise only half the inherent capacity. Under condition (*f*), with two circuits between Kitimat and the switching station on the Kildala side of the Kildala Pass out of service, the limit of power which can be transmitted is about 1600MW, so that the firm load of 1200MW can be handled with a margin of 25 per cent.

Communication Facilities

For communication between Kemano and Kitimat, power line carrier facilities will be installed. Initially there will be three duplex telephone channels, which can be expanded to five with some additions in equipment. The carrier system will also provide the voltage telemetering channel, in addition to several other similar channels if required, as well as a remote tripping scheme actuated at Kitimat. The carrier system will handle the phase-comparison relay protection if this is installed.

Broad-band coupling and trapping solved the problem arising from the multiplicity of traps necessary for ten frequencies. Reliable service was another consideration, since icing of the transmission lines may cause the signal attenuation to increase from about 2 db to 60 db, or by a factor of 100,000. To overcome this, the carrier equipment, which is equipped with automatic gain control, will operate through 63 db, or 80 db in the absence of noise. Components common to all channels are duplicated. Phase-to-phase coupling is employed, using one conductor on each of the two transmission line circuits. This will permit phase-to-earth operation in the event of loss of one circuit.

Power-Supply Facilities at Kitimat

In the initial stage the power-supply facilities at Kitimat will be as shown in Fig. 5.

The step-down transformer banks are single-phase, forced-oil, water-cooled units rated at 37MVA, with a voltage ratio of 275/13·2kV, having four 2·5 per cent taps, the neutral being solidly earthed. Each bank of the initial three is being supplied by a different manufacturer.

Each potline will be supplied by eight mercury-arc rectifier equipments of the ignitron type in the initial establishment, each rated at 12·5MW. These equipments comprise a single tank 1·2kA, 1000MVA interrupting capacity outdoor oil circuit breaker ; a self-cooled, phase-shifting transformer rated at 13·2MVA (of which two provide 15 deg. phase shift, and four 7·5 deg.) and arranged to give forty-eight phase operation ; and a self-cooled rectifier transformer rated 13·2MVA, with a three-phase primary and two six-circuit, star-connected secondary windings. These windings supply the twenty-four anodes of two rectifier frames, each consisting of twelve pumped ignitron-type water-cooled rectifiers with auxiliary equipment. The cathodes of the sixteen frames are connected through high-speed air circuit breakers to the positive main d.c. busbars. The neutral points of all secondary windings are connected to the negative d.c. busbars through inter-phase transformers. The rectifier equipment will have an efficiency in excess of 96 per cent, from the 13·2kV a.c. busbar to the 1000V d.c. busbar.

The h.v. circuit breakers and isolating switches are similar to those used at Kemano. Outdoor l.v. isolators are rated at 6kA for main connections and 1·2kA in rectifier connections.

The step-down transformer banks are protected on the primary and secondary sides by induction-type phase and neutral over-current relays. Individual transformers are equipped with gas-detector relays similar to those used at Kemano. Alarm devices are employed for the oil and water lines and for the winding temperature detectors. The rectifier transformers are protected by primary-phase and neutral relays, gas-detector relays, high-temperature and low-oil-level alarms. The rectifiers have loss-of-vacuum, reverse-current and over-temperature protection.

A master earth relay scheme discriminates between a fault on the transformer bank side of the h.v. circuit breaker, for which it is inoperative, and one on the busbar side, for which it operates. On operating, this relay scheme remotely trips the h.v. circuit breakers at Kemano by means of two-tone generators in series and two in parallel on different carrier channels, thus ensuring rapid clearance of a line fault near Kitimat or one on the busbar.

Half of the initial 300kV power cable order, one of the initial step-up transformer banks, one of the generators and part of the pressure-conduit liner steel for Kemano are being secured from United Kingdom sources. Moreover, half of the potroom cranes, the unloading crane for the harbour, the bulk-alumina unloading equipment, a number of other cranes and miscellaneous equipment for Kitimat are being purchased in Great Britain.

The Kemano hydro-electric works and the Kitimat aluminium-reduction works are being built by Aluminum Company of Canada, Ltd., the Canadian production unit of Aluminium, Ltd.

American Engineering News

(By Our American Correspondent)

Highway Bridge Across the Delaware River

An important highway bridge crossing the Delaware River between New Jersey and Pennsylvania at the Delaware Water Gap was officially opened to traffic on December 16, 1953. The bridge, which is shown in the aerial view reproduced herewith, was designed to alleviate a dangerous traffic bottleneck of long standing at this site. The structure has an overall length of about ½ mile and actually comprises two individual bridges which have been erected side by side and are carried on pedestal piers of T design. Its silhouette has been designed to detract as little as possible from the spectacular scenery amidst which it is set, and its low railings will permit the motorist an excellent view up and down the valley. The walkway, with a 5ft 6in mall being situated between the two. The ascending gradient is 0·54 per cent from south to north, the highest point being at the north, or Pennsylvania, abutment—353·24ft above sea level. The normal low water in the river is at elevation 285ft.

Fifteen piers carry the east or upstream bridge and sixteen piers carry the west or downstream bridge. The east bridge is 2398ft long, abutment to abutment; the west bridge is 2461ft in length, with the difference being due to the skewed arrangement of the piers. The east bridge consists of thirteen simple plate girder spans and a continuous girder over three spans. The simple plate girders are each 147·6ft long; the continuous girder has spans of 145ft 6in, 190ft, and 145ft 6in and a total length of 481ft. The west bridge in addition to the above spans has another span 63ft long at the north end adjacent to the abutment, to compensate for the additional length caused by the skew design. The depth of girders, back to back of angles, is 7ft 6in.

Highway Bridge at Delaware Water Gap

bridge lies well within the famous Water Gap, where the Delaware River is said to have eroded long ago the gigantic break in the Kittatinny mountain from which the district takes its name. It is the first bridge to cross the river at this particular site, although just above it may be seen the piers of the dismantled railway trestle which was once used by the New York, Susquehanna and Western Railroad.

On the New Jersey side a new four-lane highway provides access to the bridge from the east. This highway gives the motorist a new and more extensive view of the Gap and the valley beyond than was possible from the old road. The Pennsylvania approach leaves an existing highway at the northern boundary of the Delaware Water Gap borough and skirts the eastern edge of the town. Passing through a deep rock cut, it meets the bridge plaza, there opening out to eight traffic lanes through the toll booths. Because of the steep nature of the terrain and the course which the Delaware River takes as it flows through the narrow gap in the mountains, the bridge was designed to cross the stream at an angle of 28 deg. to the axis of the river, which is roughly north-south at the point of crossing. Each of the dual bridges provides a 25ft roadway for two lanes of traffic and a 5ft outside

The weight of the inside girders is 28 tons and that of the outside girders is 31 tons. The heaviest section of the continuous girder weighs 23 tons, and its depth is the same as that of the plate girders. The piers of T design, which support the bridges, are staggered at centre distances of 64ft 4 $\frac{3}{16}$in. They are of reinforced concrete construction and are faced with cut granite to elevation 322ft, about 6in above the highest recorded river flood stage of 321·6ft, which occurred in 1903. A number of the piers are supported on H-section steel pilings driven to bedrock. Each bridge roadway is carried on four girders spaced at centre distances of 8ft 8in and resting on shoes supported on the 30ft cross arms of the T-shaped piers. Cross frames tie the girders together and are spaced at centre distances of about 24ft 6in. The pavement of the bridge is of reinforced concrete construction.

The structure was built by the Delaware River Joint Toll Bridge Commission at a cost of 8,276,000 dollars. The J. E. Greiner Company, of Baltimore, Maryland, acted as consulting engineers; Johnson, Drake and Piper, Incorporated, of New York, were the prime contractors; and the Bethlehem Steel Company, of Bethlehem, Pennsylvania, fabricated and erected the superstructure.

Hot Extrusion of Mortar Shells

An interesting modification of the Ugine-Sejournet hot extrusion process using glass as a lubricant is now being applied to the manufacture of mortar and artillery ammunition by the Scaife Company, of Oakmont, Pennsylvania. Originally, this firm produced 4·2in mortar shells as a three-piece assembly of seamless tubing and machined components. Employing the new method, this shell is produced in one piece from a single billet and, according to the U.S. Army Ordnance Corps, with "improved quality and significant savings in cost and materials." Among the advantages of this development are the substitution of readily available billet stock for scarce seamless steel tubing as well as savings of 25 per cent in the weight of steel used. In arriving at the technique now being used, the company combined certain advantages of both conventional hot forging and cold extrusion processes. Hot forging permits the drastic reforming of material in a single press operation, but generally involves poor dimensional control; cold extrusion, on the other hand, provides close dimensional control, but requires many individual press operations. It has been found that the glass lubricant used in the process developed facilitates the hot press forming operation and permits better die designs providing greatly improved dimensional control.

In manufacturing the one-piece 4·2in mortar shell, having a nose adaptor integral to the body, the raw material is a slug of medium carbon steel bar, conforming to specification No. 1035 of the American Iron and Steel Institute. The slug is heated in a high-speed gas furnace to extrusion temperature. Glass, either in the form of powder or woven glass fibre, is then applied, and the slug is positioned in the press. The actual extrusion is completed in less than one second with the glass acting as a viscous lubricant between the die, the punch, and the work piece. According to the firm, the hot extrusion process results in improved surface conditions which minimise subsequent machining, in a high extrusion ratio, and in reduced extrusion pressures. An extensive programme to develop applications of the hot extrusion process to other military and commercial products is now being carried out by the Scaife Company. Future applications of the process are expected to be not only to the conventional cup-shaped forgings produced by hot piercing, but also to short tube lengths and to complicated extruded shapes similar to those now being produced in non-ferrous materials. It is felt that the process will lend itself particularly well to the manufacture of high-pressure containers, such as compressed gas cylinders and accumulator bottles and to products requiring short tube lengths of closely controlled dimensions, such as bearing races and cylinder liners. The patent rights covering the process are held by a French firm, Comptoir Industriel D'Etirage et Profilage de Metaux, Société Anonyme, of Paris.

Ultra-High-Energy Particle Accelerator

The design is now proceeding at the Brookhaven National Laboratory, Upton, Long Island, New York, of an ultra-high-energy particle accelerator to be used for nuclear research. The new machine will be an alternating gradient synchrotron and will be designed to produce beams of protons of energies ranging up to 25,000MeV. This alternating gradient synchrotron will use a series of alternate strongly converging and diverging magnetic fields to confine a proton beam in a tube of relatively small cross-section. This focusing effect allows the production of high-energy beams with smaller electromagnets and related equipment than would otherwise be possible. The cost of design and construction of the new accelerator has been estimated at 20,000,000 dollars, and it is expected that the machine can be completed in five to six years.

It is well known that as a means of producing nuclear reactions under controlled conditions on a laboratory scale, particle accelerators have played an important part in the advancement of nuclear science and have contributed much of the fundamental scientific information used in the design of nuclear reactors. The energy of the particle beams produced by accelerators

bears a direct relationship to the nuclear phenomena that can be studied. As higher energy levels have been attained in laboratory machines, new sub-nuclear particles have been discovered and new nuclear phenomena observed. The most powerful accelerator currently in operation in America is the Brookhaven cosmotron, which has accelerated protons to energies of 2300MeV. The "Bevatron," which is under construction at the University of California Radiation Laboratory at Berkeley, is expected to accelerate particles into the 5000MeV to 7000MeV range. By providing particles with energies as high as 25,000MeV the Brookhaven alternating gradient synchrotron is expected to contribute important new knowledge of the fundamental nature of matter.

Magnetic Tape Recording of Television Pictures

An important demonstration took place recently at the David Sarnoff Research Centre of the Radio Corporation of America in Princeton, New Jersey, when both colour and black-and-white television pictures were recorded on magnetic tape and played back over colour television receivers. In the demonstration a colour television programme originating in a studio of the National Broadcasting Company in Radio City, New York, was beamed by microwave transmission across the distance of 45 miles to the research centre at Princeton. As the programme arrived it was seen on two colour television receivers. At the same instant the new television tape recorder recorded the television picture and the sound on a single thin strip of magnetically coated plastic tape ½in in width. During part of this transmission both the "live" programme and an immediate play-back of the tape recording were shown, permitting the direct comparison of the recorded programme on one receiver with the "live" broadcast being received on the other. As soon as the tape reel was rewound it was played back, and the recorded television pictures appeared on the two receivers. In an earlier phase of the demonstration there was a screening of both black-and-white and colour programmes previously recorded on the magnetic tape. The same apparatus handled both the recording and the play-back of the tape for both the colour and the black-and-white tests.

The primary reason for the development of the television tape recording process was to promote the advancement of colour television. The use of the tape in colour television will eliminate the substantial time lag involved in processing colour film for television use and will prove far less expensive. When a television programme is recorded by the existing kinescope recording methods the pictures pass from the television camera through most of the television system to be reproduced on a small kinescope. A special motion picture camera then photographs the programme on film. The film must be chemically processed and, usually, a print is made before the picture can be reproduced. The reproduction requires another installation in which a television camera picks up the scene from a film projector for re-broadcast. The current kinescope recording process is time-consuming, with film processing time running to several hours in most cases. Furthermore, the quality has generally been limited, since the pictures must encounter all the hazards of both the television system and the photographic process. Although magnetic tape to-day costs more per minute of programme time than 35mm colour film, the fact that tape needs no processing before play-back compensates for the expense of raw tape. What makes the savings on tape so great, according to the company, is the fact that the programme can be electronically "wiped off" and the tape re-used, as in sound tape recording.

The R.C.A. method of television recording is similar to the techniques used to record speech and music with magnetic tape sound recording equipment. Electrical signals are impressed through a recording head—a small horseshoe electromagnet—on to the magnetically treated surface of a plastic tape. As the tape is drawn across the recording head the head continuously changes the magnetic polarity of the magnetic oxide particles on the tape so that they become a compact code of the original signal. For purposes of play-back the tape is drawn across the same or a similar head. The magnetic code on the tape causes an alternating current to flow in the windings around the reproducing head. The reproduced current closely duplicates the original signal. Although the principles are similar, the engineering problems are not; audio recording is to-day an easy task compared with video recording since audio signals are in the range of 20 c/s to 20,000 c/s, while video signals range up to 4,000,000 c/s. Colour television signals, as now formulated, in the accepted American system, must carry at least twice as much pictorial information as black-and-white signals. The video tape also must carry the associated sound signals along with this pictorial information. Recent research has resulted in the development of recording and reproducing heads which respond to frequencies many times above the cut-off point for the recording heads used in sound recording on magnetic tape. This means that the speed of the tape across the head has been brought within manageable limits. The present equipment has a tape speed of 30ft per second. Advanced equipment now under construction will move the tape at a lower speed and eventually further reduction of tape speed appears likely. The magnetic tape reels of the present laboratory equipment are 17in in diameter and will record four minutes of a television programme. The company is now working on a reel 19in in diameter which will carry a fifteen-minute programme.

In the tape recording of colour television five parallel channels are recorded on a single magnetic tape ½in in width. There is one recorded channel for each of the primary colour signals (red, green and blue) for the synchronising signal, and for the sound signal. For black-and-white recording the tape carries two recorded channels, one for the video signal and the synchronising signal, and one for the sound signal. For black-and-white television a ¼in wide tape would suffice.

New Jersey Turnpike

The latest annual report of the New Jersey Turnpike Authority indicates that both traffic and revenues reached new high levels during 1953, greatly exceeding the original estimates. The traffic in 1953 was that forecast by the consulting engineers for 1975, and the revenues from tolls and concessions showed a similar trend. A total of 22,159,084 vehicles moved over the turnpike in 1953, a daily average of 60,700, or two and one-half times the number (23,900) estimated by the consulting engineers. Of the various classes of vehicles using the road, it is interesting to note that travel by commercial vehicles continued to increase exceptionally during the year.

The record of safety of the New Jersey Turnpike has showed encouraging improvement during the past year. Part of this improvement stemmed from an increase in the State Police detachment and the subsequent greater enforcement of regulations; from changes in traffic rules to meet unsafe conditions; from an increase in traffic signs; from better procedures for handling traffic during adverse weather conditions; and from improved lighting in fog-prone areas. After careful studies of conditions in fog-prone areas it was decided to erect additional regulatory and informational signs. The most important of these were large neon-lighted signs placed at intervals of approximately 5 miles in the northern end of the turnpike, where traffic conditions are dense, to inform users of fog, ice, snow or other emergency conditions ahead. These signs carry a large message "Drive Slow," which flashes on and off to attract attention, and mention also the specific condition. The value of these signs was demonstrated in recent fog and smoke conditions. To supplement the sign and lighting programmes, a standing operating procedure was developed for use during fog conditions. Depending upon the density of fog conditions, or the lack of visibility, these are classified from "A" for light fog to "E" for extremely heavy fog. The measures to be taken by the turnpike personnel under these conditions include the informing of motorists, the placing of additional signs and warning lights or flares, and the recall to duty of off-duty personnel from the State Police detachment, maintenance and toll collection forces. The effectiveness of the new procedures was shown during the period of unexpected smoke in the Newark-Elizabeth area last autumn. While it was found necessary to close the turnpike to traffic in this area on occasion because of the smoke nuisance, potential accidents were avoided and the closing action was justified because of zero visibility. In the smoke nuisance which emanated from a dump in the Newark-Elizabeth area, immediate steps were taken by the Authority to correct the conditions in co-operation with the owners and operators of the properties affected.

The programme of research in the dispersal of fog conditions is continuing through liaison with the U.S. Navy, the Stanford Research Institute and others engaged in this field. In October last the Authority employed the services of Weathercasts of America to provide frequent detailed forecasts of weather conditions to be found on the turnpike. Additional lighting was provided at the interchanges, in service areas and between the two bridge crossings of the Hackensack and Passaic rivers to add to safety in those areas. In all, a total of 676 new mercury vapour lamp units was installed during 1953.

The staff of the Authority continues to explore means to reduce the cross median accidents, even though these have been in the minority in relation to total accidents on the turnpike. The desirability of using upper beam headlamps for night driving on the road encouraged the Authority to investigate the erection of a planted barrier at those sites where a combination of line and gradient causes opposing headlights to shine into the eyes of motorists. Extensive tests were made both on the turnpike and on an unused runway at the Newark Airport, and others will be made to determine the desirability of improving seeing distances by means of such barrier plantings. In recent months the Authority initiated a research programme to be directed by the Bureau of Highway Traffic at Yale University, seeking to improve the design of the median strip to the point where vehicles (1) may be prevented completely from crossing; (2) may be kept from being thrown into other vehicles travelling in the same direction; and (3) where the median design may minimise injury to the driver and damage to vehicles out of control. Such a design is expected to be tested early in 1954, and it is hoped that tests of the headlight protective strip may be conducted at the same time.

For all of 1953 the records of the State Police disclose a total of 584 accidents on the turnpike, equal to 67·1 for each 100 million miles of vehicular travel. This rate was a reduction of 27·6 per cent compared with 1952, when it was 92·7. During 1953 there were twenty-six fatal accidents on the turnpike, causing death to thirty-six persons, which represent reductions of 21·2 per cent and 23·4 per cent, respectively, compared with 1952. The fatalities in 1953, using the standard basis of comparison of the American National and State Governments, were equal to 4·14 per 100 million miles of travel. The 4·14 rate on the turnpike ranks with the lowest rates for vehicular fatalities in the whole country, particularly as the safety record of the turnpike must be considered in conjunction with the extraordinarily heavy traffic which it is carrying.

Current planning by the engineering staff of the Authority includes a consideration of the increase in traffic volume on the turnpike in connection with the completion of the connection to the Pennsylvania Turnpike below Bordentown. Traffic studies have indicated the need for an additional traffic lane on the turnpike in each direction between the Camden-Philadelphia interchange and the Woodbridge-Amboys interchange, and between the George Washington bridge and the Lincoln Tunnel interchanges. Sufficient right of way is available for the additional lane, as, whenever practicable, the structures on the turnpike were designed to accommodate additional lanes. Since the work of widening must be accomplished under operating conditions on the present road, planning also must consider the method and manner in which traffic may be kept moving safely while work is being performed.

The planning and designing of the Newark Bay-Hudson County extension continued

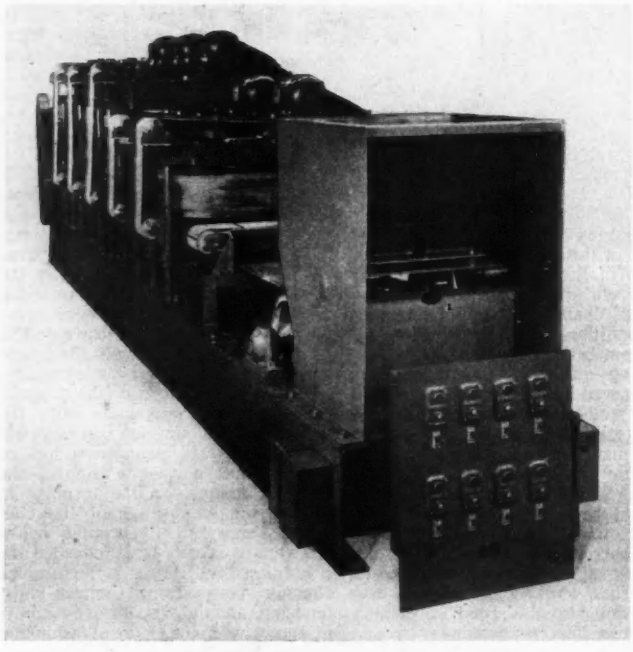
throughout the year. Plans were formulated so that the Newark Bay crossing, which is the most difficult part of the present extension, would be advertised for competitive tenders as soon as financing arrangements were assured. Meanwhile orders for the structural steel required in the crossing were placed for early mill rolling. Contracts were awarded to the lowest bidders for the foundations and the superstructure of the Newark Bay bridge. The planning of the connecting links on both the easterly and westerly ends of the bridge is now progressing.

Magnetic Ore Separator

THERE was recently completed at the works of Rapid Magnetic Machines, Ltd., Lombard Street, Birmingham, a large mineral separator for a concern in Tasmania. This machine, a "Dings" design cross belt magnetic separator, has five cross belts and is 20ft long.

In this design of separating equipment for fully magnetic ores, a number of cross belts are arranged over a main conveyor belt and at each cross belt station a material of different magnetic susceptibility in the main ore stream is picked up and removed. The strongest magnetic material is removed at the first cross belt station and the weakest at the last station by the most powerful magnetic cross belt unit. The non-magnetic content of the material is carried away on the main belt and discharged at the end of the plant.

The new separator built for Tasmania can be seen in the accompanying illustration. Its main frame consists of an assembly of two heavy steel channels and cross members. The head pulley of the ¼in thick main conveyor belt of rubber and canvas is driven through chains by a ½ h.p. motor and reduction gearing. A steel hopper at one end of the plant feeds material to the conveyor belt through a mechanically vibrated tray, which ensures a constant and even flow. At each of the separating stations of the plant a rigid structure supports a self-contained magnetic unit and cross belt assembly. Each of these assemblies consists of the pick-up poles, steel core and magnetising coil around which,



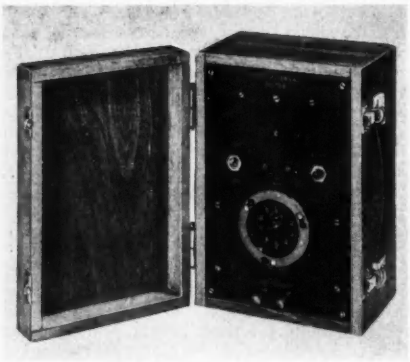
Feed End and Control Panel of Magnetic Ore Separator

on four aluminium pulleys, a rubber and canvas cross belt is driven by a ½ h.p. motor. The first cross belt has a permanent magnet which removes the highly magnetic content of the material being handled.

The makers state that these machines can be supplied with main conveyor belts in three sizes, 6in, 12in and 18in wide, and the number of cross belts used can be varied to suit the application, but seven belts are usually the economic limit. The capacity depends upon the characteristics of the material being separated and is stated by the makers to range from 50 lb to 150 lb per inch of magnet width. An 18in wide main conveyor with seven cross belts is said to have a current consumption of 6750W, whilst that for a 6in main belt with one cross belt is 800W.

Time Interval Meter

OUR illustration shows a time interval meter which is designed to start and stop an associated stop-watch by the discharge of condensers through an operating relay, after the closing of contacts in an external circuit. The instrument



Self-Contained Time Interval Meter

was developed by the timing division of Camerer Cuss and Co. in association with Allied Electronics, Ltd. It is housed in a hardwood case (9⅞in by 6in by 6⅞in), fitted with a removable hinged lid and a carrying handle, and, being battery operated, the instrument is completely self contained. Two Ever Ready "B105" batteries are incorporated in the instrument case.

Times are recorded automatically by means of a standard stop-watch which is carried in the instrument (as illustrated here) and is started and stopped electrically. The design is such that when the two external circuit terminals are momentarily connected electrically (for at least 10 milliseconds) the watch will start and continue to run until the terminals are again connected for a similar period. Resetting to zero is effected by a built-in push button or by remote control. Any kind of remote control can be used, but, for the correct operation of the circuit, the time between the release of the initiating pulse and the start of the terminating pulse should not be less than 500 milliseconds and the resistance between the terminals should not exceed 12,000 ohms.

By means of adaptor mounting rings the instrument can accommodate two sizes of stop-watch. The main restriction on the choice of stop-watch for use with the instrument is that the circuit is designed to measure periods down to, but not less than, half a second. For general use the maker recommends the Camerer Cuss Model 308, stop-watch, which is designed to conform with the requirements of the Ministry of Fuel and Power (Electricity Supply Meters Act, 1936) and has a $^{1}/_{50}$-second escapement.

An abstract from an N.P.L. report on the instrument is reproduced in the following paragraphs.

"A standard electronic counter chronometer was used to determine the variations in the time interval between the closing of the contacts and the receipt of the impact causing the operation of the push-piece of the stop-watch.

"Under given conditions, including any particular value of external resistance up to 12,000 ohms, the interval was found to be constant to well within 0·002 second.

"When the resistance in the external circuit was varied from 0 to 12,000 ohms the interval was found to change linearly by 0·012 second.

"Although this change is scarcely significant in relation to the errors inherent in any stop-watch, in service it can be eliminated by adjusting the start and stop circuits to be of equal resistance."

Corrugated Aluminium Roofing Sheet

DURABILITY and first cost are the two main factors which a designer has to reconcile when making the choice of material for roofing industrial buildings. Although in pre-war days labour and service costs were not very high and so permitted the use of cheap materials, present-day conditions call for a material having sufficient durability to ensure low maintenance charges. Apart from the question of durability, the material chosen must have sufficient strength to

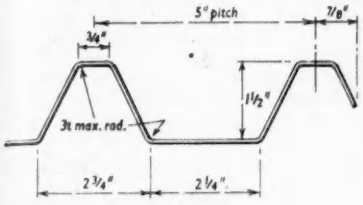
Typical Installation of Corrugated Aluminium Roofing Sheet

enable it to be used economically in self-supporting sheets so that extensive supporting roof work is not required.

To-day aluminium is becoming recognised as a cladding material fulfilling the necessary requirements. Its weathering characteristics are high and tests during recent years have demonstrated its high resistance to attack. The pure metal has high resistance to corrosion, but it is soft and it has been alloyed with 1¼ per cent manganese to produce an alloy conforming with British Standard Specification N.S.3, which has a high corrosion resistance and an ultimate tensile stress of 12–14 tons per square inch. The results of corrosion tests show that sheet, 0·036in thick, made to specification N.S.3 by the Northern Aluminium Company, Ltd., could be expected to have a life of fifty years in severe environments or one hundred years in tropical or rural conditions, allowing a factor of safety of two. The comparative figures for galvanised steel sheet having a zinc coating of 0·75 oz per

square foot on each side are 5·5 years in industrial, ten years in urban, sixteen years in coastal, and twenty-five years in rural areas, with no factor of safety allowance. The corrosion rates of the alloy also compare favourably with those of copper and zinc.

Although the metal itself may be suitable, it must be applied in a specially designed form, which takes full advantage of the characteristics of the material, be sufficiently rigid to span at least 7ft 6in and allow maintenance men to walk on it without causing local damage.



Profile of Sheet

The profile as shown by development work, carried out by Aluminium Laboratories, Ltd., and the Aluminium Development Association, to fulfil requirements is an asymmetrical section, as seen in our drawing, with deep straight sided corrugations and wide troughs for water shedding and capable of withstanding a concentrated load of 200 lb on a 5in square. This new corrugated sheet, made by the Northern Aluminium Company, Ltd., Banbury, and illustrated on page 474, has a standard thickness for roofing purposes of 20 S.W.G. and 22 S.W.G. for siding. The roofing sheet can span up to 9ft, so that the number of purlins and attachments can be reduced with similar effect upon cost and weight.

Aerating Cone for Sewage Purification

THE aeration of settled sewage in the activated sludge method of purification may be effected by various methods. About thirty years ago, Ames Crosta Mills and Co., Ltd., Moss Iron Works, Heywood, Lancs, introduced a method of surface aeration known as the "Simplex" process, in which the settled sewage flows into aeration tanks comprising two or more square pockets in the form of inverted truncated pyramids; in each pocket there is a stationary uptake tube surmounted by a mechanically driven agitator or cone. The liquid level in the tank is at about the lip of the cone, and rotation of the cone scatters the liquid over the surface of the tank, thus drawing liquid up the tube and creating a circulation and, hence, an aeration, of all the liquid.

An improved form of this equipment, known as a high intensity cone, has now been introduced by the firm. The form and disposition of the blades have been modified, and the dimensions and speed of revolution of the cone have been altered. The form of the high intensity cone, with its operating gear above it, can be clearly seen in the first of our illustrations. In operation it is intended to lift gently a large volume of sewage, which then pours over the lip of the cone, giving a vigorous wave motion outwards over the surface of the tank, as shown in our second illustration. The area of liquid in contact with atmospheric oxygen is increased by this wave action, and the circulation of liquid is about three times faster than with the older cones, the entire contents of a tank circulating in about five minutes. The makers state that for an equivalent volume of aeration tanks, 50 per cent more sewage can be treated with the high intensity cones than with the old cone, and the power consumption per unit volume of sewage is reduced by about 8 per cent. The high intensity cone shown in our first illustration is shown installed at an old works, and the uptake shaft, tanks and operating gear were previously in use with the old cone, which has been replaced to increase the capacity of the installation.

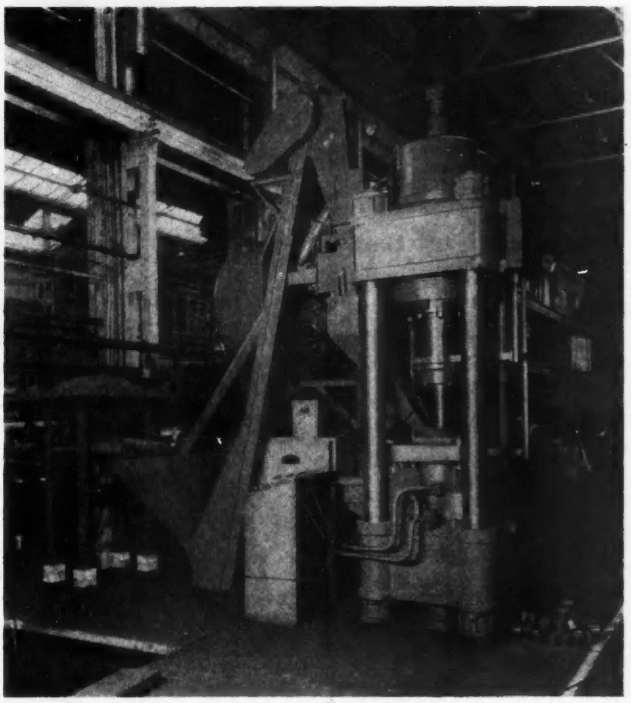
High-Intensity Cone and Aeration Tank

Cast Iron Swarf Briquetting Press

A 400-TON hydraulic briquetting press for cast iron swarf now being made by Fielding and Platt, Ltd., of Gloucester, is illustrated on this page. This machine is supplied complete with its own hydraulic pumping unit, and is designed to work on an automatic cycle. It produces five or six high-density briquettes a minute, each weighing from 4 lb to 6 lb.

With this equipment swarf for briquetting is loaded into a bunker of 1 ton capacity, situated near the machine, and from the bunker it drops on to a vibrating screen, which removes any large pieces of metal. The screened material drops into the boot of an elevator and is carried to a small hopper at the top of the machine. This hopper is fitted with a vibrator, which prevents the swarf packing and ensures a continuous

Surface Agitation with High-Intensity Cone in Operation



Briquetting Press for Cast Iron

supply of material to a dispenser below. When a predetermined weight of swarf has been deposited in this dispenser it is tipped by a pneumatic cylinder and its contents gravitate down a chute into the mould cavity of the press. The dispenser then returns to its filling position while the press ram descends to compress and form the briquette. On the return stroke of the ram the briquette is ejected from the mould and pushed off the press table by a pneumatic unit.

The makers point out that with certain modifications this machine can be adapted for briquetting certain non-ferrous swarf, such as brass and aluminium.

Accelerated Continuous Carbonisation by the Rochdale Process

A NEW gas making process has been developed as a result of experiments carried out during the past two years with orthodox carbonisation retorts at the Partington and Rochdale works of the North Western Gas Board. It is stated that if the results achieved in the pilot plants are fulfilled in full-scale practice, the gas industry will be able to save millions of pounds in capital costs and annual running costs.

In the pilot plants coal has been carbonised in half the time taken by conventional carbonisation methods, and throughputs of coal have been more than doubled. The production plant capital charges per therm of gas produced have been almost halved and the heat required for carbonisation has been materially reduced. Furthermore, it has been possible with the North Western process to use coal slack without loss of productivity, while actually making better qualities of coke with less breeze.

According to a statement by the North Western Gas Board, there is a possibility that low-grade coal normally unsuitable for gas making may be successfully carbonised by this process.

The method used is a development of one patented some thirty years ago, but never until now brought beyond the experimental stage. It consists of injecting gas into the base of the standard vertical retort during carbonisation. This has been found to accelerate greatly the speed of gas making. In the retorts used in the experiments throughputs of the order of 14 and 15 tons per day—more than double the normal capacity—have been regularly achieved, and it is thought that even this does not represent the final limit of productivity.

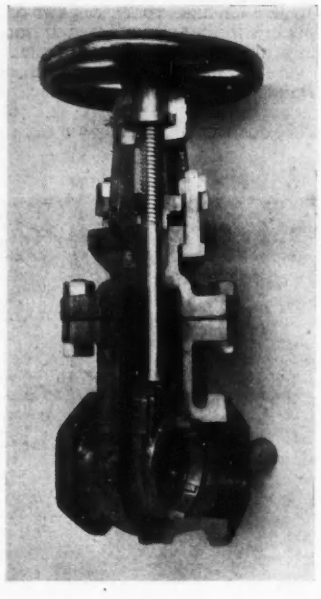
The results of the tests have been communicated by the North Western Gas Board to the Ministry of Fuel and Power and to the gas industry in a formal report. The process is outlined in a paper entitled " Accelerated Continuous Carbonisation by the Rochdale Process," which was presented before the Manchester and District Section of the Institution of Gas Engineers on March 12th by Mr. Tom Nicklin and Mr. M. Redman.

Re-Designed Gate Valve

WE are informed by Crane, Ltd., 45–51, Leman Street, London, E.1, that its standard cast iron wedge gate valves are now being made with a tee-head connection between the disc and the stem. These valves, which are supplied in sizes from 2in to 12in, are of the outside screw and yoke design and, according to the size, have screwed or flanged connections.

The new form of construction can clearly be seen in the sectional photograph we reproduce herewith. In it an integral tee-head formed on the end of the stem fits easily into an undercut slot on the top of the disc. This arrangement is such that whilst it gives a safe connection and allows good seating of the disc, there is a sufficient degree of flexibility to avoid lateral deflection in the stem. Other improvements incorporated in the redesigned valves include straight-through ports—no recess being formed behind the seat rings—and the solid wedge disc with machined guides reduces drag on the seat surfaces. A two-piece, self-aligning gland is fitted, and a particularly deep stuffing box is also now used.

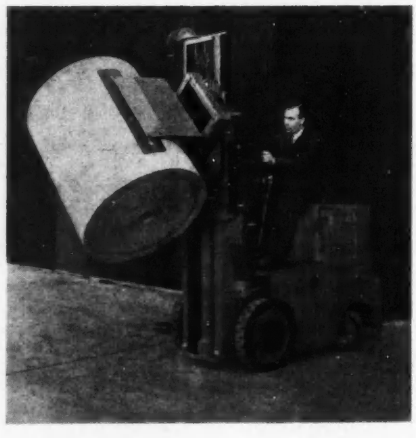
When valves of this design are supplied to the petroleum industry they are made to the requirements of B.S. 1735 : 1951, Class 125, and connections can be made for British or American Standards.



Gate Valve with Tee-Head Stem-Disc Connection

Rotating Reel Clamp for Fork Trucks

A ROTATING reel clamp attachment for its fork lift trucks has been introduced by Conveyancer Fork Trucks, Ltd., Liverpool Road, Warrington. The clamp is designed to handle closely wound rolls of paper and other materials from 24in to 42in diameter, gripping and stacking them either vertically or horizontally. The clamp, which can be seen in the illustration below, is fitted to the standard carriage of the truck and is interchangeable with other accessories.



Rotating Reel Clamp Handling a Large Reel of Paper

The clamp has two arms one of which is fixed, the other sliding on rollers in a channel frame. Twin hydraulic jacks anchored in the channel frame actuate the sliding arm ; these jacks extend to close the clamp and retract to open it. A pivoted gripping pad is attached to each arm and these pads are spring loaded so that they are presented in the open position to a roll. A plate upon which the arm assembly is mounted rotates on a bushed spigot on a fixed back plate designed to hook on the truck carriage. The clamp unit is rotated by two hydraulic jacks mounted tangentially between the front and back plate, and during the rotating movement the front plate is supported by three bracket-mounted rollers.

The operations of gripping and rotating are controlled by a separate hydraulic valve assembly which is additional to the normal lift and tilt controls of the truck. When it is required to pick up a roll laying on its side on the floor the truck mast is first tilted forwards and the carriage lowered so that the lower, fixed, arm can be positioned right into the roll side whilst the upper, sliding, arm is set across the top to give the maximum possible embrace. The roll can then be lifted, turned and stacked in a vertical position if so desired. Alternatively, rolls standing on their ends can be raised and turned and placed in position on machines horizontally or, if required, at any angle.

Overhaul of a Large Caisson Gate

THE removal and drydocking for major overhaul of the caisson gate of the King George V Dry Dock at Southampton has recently been completed. The caisson has not been drydocked since 1933, when it arrived in tow from the builders, the Furness Shipbuilding Company.

It was originally intended to dock the caisson in No. 6 (Trafalgar) dry dock, where it could have been cradled in its normal upright position. This would have meant, however, that for a time Southampton's two largest dry docks would have been out of action. It was therefore decided to put the caisson into one of the smaller dry docks, No. 3, which necessitated the caisson being turned over on its back in a horizontal plane, with a draught of 13ft, as compared with 31ft 9in in the upright position. The principal dimensions of the caisson are :—Length, 141ft 9in ; breadth, 29ft 6in ; height, 58ft 6in. When the King George V dock is dry the total water pressure against the caisson at high tide is about 6000 tons. The weight of the caisson, including some permanent concrete ballast, is 1870 tons. The total weight, with the water ballast and in working condition, is 4690 tons, but when the dock is flooded and the caisson is moved into position its displacement is about 4655 tons.

The caisson is divided horizontally by three intermediate watertight decks. The top compartment is open to the tide, the inner, or dock, side skin plating preventing water from entering the dock. The second compartment from the top is an air chamber and contains a pump and piping which can be used for pumping water ballast from the tanks in the next lower compartment. The third compartment from the top is divided into three tanks by two vertical cross bulkheads ; in working condition all three of these tanks are full of water, but can be emptied by using the pump in the air chamber. If all three tanks are emptied the caisson will float with a draught of 31ft 9in and will still be stable in the upright position. The bottom compartment is also full of water, but if even a small quantity is pumped out the caisson is no longer stable vertically and will take up an inclined position.

Thus to turn the caisson from the vertical to the horizontal position meant pumping out most of the water from the bottom compartment. This operation was a tedious one, as the fixed caisson pump could not be used for dewatering the bottom compartment. A small portable submersible electric pump had to be lowered through an access trunk to the bottom chamber, and it took twelve hours' continuous pumping to remove about one-half of the water. It was then possible to get a second pump to work and the remainder of the operation was completed in a further seven hours. The total quantity of water removed in the nineteen hours was 1460 tons. This work is under the direction of Mr. J. H. Jellett, O.B.E., the docks engineer, and the pumping operations under Mr. E. S. Ely, the docks mechanical and electrical engineer.

CONTROL OF WEEDS.—We have received from Borax Consolidated, Ltd., a pamphlet which gives specific data concerning " Boraseu," which it is claimed provides effective control of weeds and grasses and as such it is suggested should prove of value to oil refineries, factories, gas, electricity and water undertakings and railways.

Industrial and Labour Notes

Engineering and Shipbuilding Wages

On Wednesday of last week there was a meeting of representatives of the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions, and on the following day there was a similar meeting between the union representatives and the Shipbuilding Employers' Federation. At both meetings the wages dispute was discussed in the light of the reports of the Courts of Inquiry which were set up by the Minister of Labour to examine the matter.

It will be recalled that the Courts of Inquiry expressed the view that there was some justification for an increase in consolidated time rates, but not to the extent of the 15 per cent originally claimed by the unions. The suggestion made by the courts was "something in the region of one-third of the amount claimed." At last week's meetings the employers' federations offered to increase wage rates by about 5 per cent, which would mean an increase of approximately 7s. 4d. a week for skilled men and 6s, a week for unskilled men. That offer, however, was not acceptable to the union representatives. A meeting of the executives of the thirty-nine unions comprising the Confederation of Shipbuilding and Engineering Unions was arranged for Wednesday of this week.

Wage Negotiations

In these notes last week, we recorded that the British Employers' Confederation, the nationalised industries and the economic committee of the Trades Union Congress had signified their willingness to consider a suggestion for the establishment of an impartial body to study the economic implications of wage claims. That suggestion was put forward in the reports of the Courts of Inquiry which have recently investigated the wages disputes in the engineering and shipbuilding industries.

Last Friday, the Minister of Labour, Sir Walter Monckton, Q.C., had an informal discussion with members of the T.U.C. general council about the different forms of wage negotiating and arbitration machinery in various industries. During this discussion the suggestion about the "impartial and authoritative body," mentioned in the reports on engineering and shipbuilding wages, was considered. An official statement issued after the meeting said that the members of the T.U.C. general council agreed that they would give further attention to the suggestion when the present difficulties in the engineering and shipbuilding industries were resolved.

On Monday, the Minister of Labour had a similar informal talk with representatives of the British Employers' Confederation. The Confederation's representatives undertook to put the suggestion concerning an "authoritative and impartial body" before a special meeting of the appropriate committee later this week. Methods for the strengthening of collective bargaining and arbitration machinery were also discussed by the Confederation's spokesmen and the Minister.

Britain's Overseas Trade

The final figure given by the Board of Trade as the value of United Kingdom exports in February is £201,100,000. The fact that there were only twenty-four working days in February, compared with twenty-six in January, mainly accounted for the decline. Taking the two months, January and February, together, however, exports of United Kingdom goods were valued at £213,500,000 a month, which was 7 per cent below the monthly rate in the last quarter of 1953, but was higher than the monthly average in any other quarter last year.

The Board of Trade says that in January and February the value of exports of engineering products averaged £83,000,000 a month, which was nearly £2,000,000 above the average in the second half of last year, and 6 per cent higher than in the comparable months of 1953. Machinery exports, apart from electrical equipment, declined in February to £31,000,000 from £36,000,000 recorded in January, but the average of £34,000,000 for the two months was £1,000,000 above the monthly average in the latter half of last year. Exports of textile machinery in January and February were slightly above the average of the preceding six months, but exports of machine tools and excavating and earth-moving equipment were lower. Exports of electrical machinery, apparatus and appliances averaged £14,000,000 a month in January and February and were thus slightly higher in value than in the second half of last year. There was a small drop during the first two months of this year in exports of railway vehicles, but shipments of road vehicles and aircraft showed some increase. Exports of ships and boats in January and February averaged over £4,000,000 a month, mainly on account of the high figures recorded in January for Liberia and Panama. In the scientific instruments division exports in the first two months of this year were a little above the monthly average for 1953.

Coal Production

Coal output in Great Britain last week totalled 4,601,200 tons, of which 4,388,100 tons came from deep mines and 213,100 tons from opencast workings. The deep-mined production last week was lower than in the comparable week of 1953, most of the loss being caused through disputes. In the first eleven weeks of this year coal output has totalled 50,602,200 tons, against 50,585,000 tons in the corresponding period of last year. The number of workers on colliery books in the week ended March 13th was 709,700, or about 7000 fewer than a year earlier. Coal consumption this year has been slightly higher than in the comparable period of 1953, and in the first ten weeks totalled 50,334,000 tons, which included 2,665,000 tons exported. Total distributed stocks of coal on March 13th amounted to 13,392,000 tons, compared with 12,756,000 tons a year earlier.

Industry and National Service

Last week, there was held at Ashorne Hill, Leamington Spa, a two-day conference to discuss industry and national service. It was arranged by the War Office and the Air Ministry in collaboration with the British Association for Commercial Education, and was attended by representatives of sixty industrial concerns.

The training, education and employment of national service men, and all aspects of their "pre-service preparation" were fully discussed at the conference. The proceedings were summed up by Major-General C. Lloyd, director of the technology department of the City and Guilds of London Institute, who congratulated the Services on the thoroughness of their plans. He thought, however, that there was need to ensure that those plans were implemented at the lower levels of command. He referred to the need for a wider spread of pre-service training courses, such as had been developed by a number of firms, and some suggestions were made as to how these courses could be applied in smaller industrial concerns. Major-General Lloyd commented that it was clear that industry did not fully understand service nomenclature and the content of service trades, and advanced the suggestion that there should be some publication which co-related the content of industrial with service trades.

Statistics and Cost Accountancy

A regional conference, organised by the Bristol, South Wales, Birmingham and Coventry branches of the Institute of Cost and Works Accountants, was held at Cheltenham last Saturday. The papers presented for discussion included one by Mr. R. Glendinning, of the British Transport Commission, which dealt with the relation of statistics to cost accountancy.

In his paper, Mr. Glendinning put forward a plea for a higher degree of knowledge about statistics on the part of the accountant in industry. He said that, unfortunately, at present few accountants knew enough about statistics, and he suggested also that few statisticians were sufficiently familiar with accountancy theory and practice. Mr. Glendinning went on to explain how cost accountancy made use of statistical methods, and referred to operational research as a statistical application of the greatest importance to industrial accountants. It was difficult, he said, to draw the line between operational research on the one hand and the ordinary processes of cost control or of managerial control on the other. A characteristic of operational research, however, was that it involved to a considerable degree the application of the theory of probability to business problems, and the accountant must therefore have some familiarity with it. Whatever might be the limitations of statistical methods in providing information for management, Mr. Glendinning asserted there could be no doubt about the great and increasing importance of those methods.

Another of the papers presented at the conference was by Mr. R. J. Gibbens, of the Imperial Smelting Corporation, Ltd., who dealt with the practical application of modern cost techniques. It was concerned principally with budgetary control and standard costing. The final paper, by Mr. F. T. Pearson, was on the subject of management accountancy in jobbing industries.

Lead Development Association

An announcement has been made this week about the formation of the Lead Development Association, the objects of which are to extend the knowledge of lead in its many uses. The Association, which is a non-profit making body, is sponsored by the leading Commonwealth producers of lead. The Lead Industries Development Council, which has hitherto been concerned with lead sheet and lead pipe, has changed its name to the Lead Sheet and Pipe Council and will continue its activities as an associate member of the Lead Development Association. The offices of the Association and of the Lead Sheet and Pipe Council are at Eagle House, Jermyn Street, London, S.W.1.

Economic Outlook

In his chairman's statement at the annual general meeting of English Electric Company, Ltd., which was held in London on March 17th, Sir George Nelson expressed his belief that in spite of greatly increased competition in overseas markets, this country's economic position could continue to improve. It was essential, he said, to maintain our technical lead by continuing the energetic pursuit of scientific research and by imaginative application of its results.

Increased production, Sir George continued, was a responsibility of management and workpeople alike. It could also be aided by a Government fiscal policy which progressively reduced the burden of personal taxation, thereby providing incentives and rewards for greater efforts which in turn would bring savings for investment in new industrial enterprises. Sir George said also that this country must continue to devise more efficient methods of production and that workpeople must in their own interests make every effort to produce maximum outputs. The managements of industry, he considered, must give their workpeople every opportunity to earn reward for extra effort, and additional earnings should arise solely from that avenue based on a stabilised basic wage, for increases in wages unrelated to output made no contribution to the improvement of the economic position of the worker or of the country. They increased the cost of production and in so doing lowered the purchasing power of the pound, and, Sir George added, made this country less competitive in the export markets. This complicated issue, Sir George commented, was not perhaps an easy thing for everyone to understand, but by providing incentives and by removing restrictions upon production could come the greatest contribution to the solution of our problems and to the maintenance at least of our present standard of living.

Notes and Memoranda

Air and Water

"VALIANT" PRODUCTION.—We understand that the production Vickers "Valiant" bombers are well able to fly when lightly loaded and in conditions of light wind from the 1288-yard runway at Brooklands, Weybridge. Under these conditions one aircraft recently became airborne after rolling 600 yards.

LIVERPOOL STEAM SHIP OWNERS' ASSOCIATION.—At the annual meeting of the Liverpool Steam Ship Owners' Association, Mr. H. Leslie Bowes, C.B.E., the managing director of the Pacific Steam Navigation Company, was elected chairman in succession to Mr. Colin C. Black, and Mr. F. H. Dawson, C.B.E., a director and general manager of the Cunard Steam Ship Company, Ltd., was appointed vice-chairman.

WEATHERTIGHT SHIP'S WINDOW.—We are informed that the Carron Company, Falkirk, has introduced a new ship's window in which the frameless glass is balanced with spring-operated lazy tongs and slides in rubber-lined bronze guides fitted to the mild steel frame. The glass is held in any position by locking it against the rubber lining at the sill by means of a lever locking device, while two spring clips hold the glass when closed. The windows are produced in a range of sizes with straight or curved tops and as a complete unit ready for fitting.

LAUNCH OF H.M. PATROL BOAT.—H.M. Fast Patrol Boat "Dark Hunter" was launched from the Fife yard of J. N. Miller and Sons, Ltd., on Thursday, March 18th. The boat, which is of composite construction, aluminium alloy frames and deck, has a length overall of 71ft 4in and a beam of 19ft and is designed to serve as a gunboat or a torpedo boat. As a gunboat the armament will consist of a 4·5in gun and a single Bofors gun or two single Bofors guns, while in the latter role, four 21in torpedo tubes and a small gun will form the armament.

RUSSIAN ICEBREAKERS.—We are informed that the three Russian icebreakers, at present under construction at the yard of N.V. Koninklijke Maastschappij de Schelde, Flushing, the first of which, the "Lena," has completed successful trials, have d.c. main propulsion equipment supplied by the British Thomson-Houston Company, Ltd., Rugby. Each set of machinery includes four 1392kW, 400V d.c. generators driven by diesel engines at 360 r.p.m., and an 800V double-unit propeller motor which develops 7000 s.h.p. at 150 r.p.m. Control is on the constant-current principle, there being two main circuits, each consisting of two generators and one half of the propeller motor, and each being controlled by amplidynes acting as exciters for the generator and motor fields.

I.N.A. AUTUMN MEETING.—The autumn meeting of the Institution of Naval Architects will be held in Torquay between September 21st and 24th, and the following is the provisional programme. On Tuesday morning, September 21st, the William Froude memorial, built on the site of the original experimental tank at Chelston, will be unveiled, followed by luncheon at the Grand Hotel, Torquay. In the afternoon a visit will be paid to William Froude's birthplace at Dartington Hall, near Totnes. Four papers will be read on Wednesday, September 22nd, in the Grand Hotel, two in the morning and two in the afternoon, namely, "Admiralty Experiment Works, Haslar," by Dr. R. W. L. Gawn; "B.S.R.A. Resistance Experiments on the 'Lucy Ashton,' Part III"; "The Measurement of Power," by Dr. T. W. F. Brown; and "Scale Effect Experiments on Victory Ships and Models, Part I," by Professor Dr.-Ir. W. P. A. van Lammeren, Dr.-Ir. J. D. Manen, and Ir. A. J. W. Lap. An all-day visit either to the Royal Naval Engineering College, Manadon, or Devonport Dockyard has been arranged on Thursday, September 23rd, and the meeting will end at midday on Friday at the conclusion of the reading of the following papers: "Experiments with a Low Drag Hydrofoil," by Mr. R. L. Townsin; and "Sideways Launching of Ships, Part I, Trawlers," by Mr. D. J. Doust.

Miscellanea

IRON AND STEEL PRICE CHART.—We have received a copy of the thirtieth edition of a chart of British iron and steel prices, which is prepared by W. Richards and Sons, Ltd., Britannia Foundry, Middlesbrough. This new edition shows graphically the prices of the principal descriptions of iron and steel over the years from 1914 to 1953.

RESEARCH FELLOWSHIP IN METALLURGY.—The Senate of Sheffield University has appointed Dr. A. R. Entwistle to be the first United Steel Companies' research fellow in metallurgy. The fellowship, which was recently instituted by the United Steel Companies, Ltd., is tenable in the University of Sheffield for research in ferrous metallurgy. Dr. Entwistle will study the effect of interstitial elements on the formation of martensite.

BRIXTON SCHOOL OF BUILDING.—Brixton School of Building, the oldest building school in the country, celebrates its golden jubilee this year. In fifty years some 30,000 students have passed through its classrooms and workshops. It is planned that the jubilee celebrations will take place next November.

COURSES ON WORK SIMPLIFICATION.—A series of courses on work simplification, for training officers, personnel managers, production managers and supervisors is being given at Roffey Park Institute, Horsham, Sussex. The courses are arranged by the British Association for Commercial and Industrial Education and the National Institute of Industrial Psychology, in co-operation with the Roffey Park Institute. The third and fourth courses in the series are to take place in the five days beginning May 10th and September 27th respectively, Mr. Winston Rodgers, of the Department of Scientific and Industrial Research, being the principal tutor. Full details of the courses are available from the Education Officer at the Roffey Park Institute.

REJUVENATING STORED PAINT.—When paint has been stored for a long time in tins its preparation for use is often a matter of some difficulty, and often it is necessary to add thinners to enable the stiff sediments to be remixed by hand. In order to overcome this generally unsatisfactory and difficult work a rejuvenating or shaking machine has been developed by Steele and Cowlishaw, Ltd., Hanley, Stoke-on-Trent. The unopened cans are clamped upside down in this machine and subjected to violent mechanical agitation which is stated to restore the paint quickly without any loss of its original properties

FUEL AND POWER IN THE CHEMICAL INDUSTRY.—A symposium on fuel and power in the chemical industry is being arranged by the Graduates' and Students' Section of the Institution of Chemical Engineers. It will be presented on April 23rd at the Battersea Polytechnic, London, S.W.11. At the morning session, beginning at 10 a.m., Dr. A. Parker, of the Fuel Research Station, will speak on "World Energy Resources," after which papers on "The Production of Power from Fuels" will be discussed. At the afternoon session, beginning at 2.15 p.m., the papers for discussion will deal with "The Application of Power to the Chemical Industry" and "Trends in Fuel Economy."

TAPERED ROLLER BEARINGS IN ROLLING MILLS.—Last week a preview was given in London of an interesting and instructive new film made for British Timken, Ltd., entitled "Tapered Roller Bearings in Rolling Mills." This film first shows some of the many uses to which steel is put and emphasises the important part which heavy duty precision bearings play in its efficient and economic production. It then describes in a comprehensive way the processes involved in the manufacture of Timken tapered roller bearings, and the care taken to ensure the high standard of accuracy which is necessary to give efficiency in operation. The film runs for nearly half an hour and is available with a commentary in French as well as in English, and a German version is now in course of preparation.

THE MECHANICS OF SAWING.—A recently published Forest Products Research Bulletin is entitled "Mechanics of Sawing: Band and Circular Saws." The bulletin deals with the effect on the performance of band and circular saws of such factors as cutting and feed speeds, the dimensions and condition of the teeth, their paths in the wood and the class of timber being sawn. The effect of the variation of these factors is considered in terms of power demand, feed resistance and rate of blunting of teeth. The cutting action of both types of saw is analysed and the relation between the dimensions of the wood removed and the conditions of sawing are discussed. The bulletin deals only with the theory of sawing and not with the maintenance of saws. It is available from Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2, price 1s. 6d.

NICKEL PRODUCTION REPORT.—The annual report of the International Nickel Company of Canada, Ltd., shows that its total tonnage of ore mined for the year 1953 exceeded 13,000,000 tons. The report states that large-scale oxygen flash melting of copper concentrates was carried on throughout the year. By the end of the year a unit was put into operation permitting treatment in a single furnace of all the copper concentrate from its ore supply. Rich sulphur dioxide gas from this process was delivered to the adjacent plant of Canadian Industries, Ltd., for production of liquid sulphur dioxide. Approximately 37,000 tons of liquid sulphur dioxide were produced and shipped to paper plants in Ontario and Quebec. In September the company began construction of a plant which will initially treat 1000 tons a day of nickel-bearing pyrrhotite. This plant, estimated to cost 16,000,000 dollars, is the first unit of an operation which will ultimately recover 1,000,000 tons per year of iron ore in addition to nickel. This iron ore will be higher in grade than any now recovered in quantity in North America, and will command a premium price for direct use in open-hearth and electric furnace steel production in Canada and the United States. Until now, world nickel production has been based on processes in which the iron content of the nickel ore is rejected in slag and tailings.

DIESEL ENGINE MANUFACTURING DEVELOPMENT.—On Friday last we were invited to visit the Eastfield Works, Peterborough, of F. Perkins, Ltd., to see in particular the production of the firm's "P" series of diesel engines. Following the visit, the company gave a luncheon at the Town Hall, Peterborough, to a large party of guests from this country and from France. At the luncheon, Mr. Frank Perkins, chairman and managing director of F. Perkins, Ltd., announced arrangements which have been made for the production of the "P" series of diesel engines in France. For some time the French company, F. Perkins S.A., has been responsible for the sale of these engines in France. Under the arrangements now completed, however, the engines are to be made by Ateliers G.S.P. at its Courbevoie factory. For the present the French firm will assemble the engines from British-made components, but ultimately the production at Courbevoie will be from components made in France. The components of the British and French produced Perkins diesel engines will be interchangeable. A toast to the British and French companies was proposed by the Mayor of Peterborough, Councillor A. Lister Robinson, and by Mr. Harmar Nicholls, M.P., and was acknowledged by Mr. Frank Perkins, on behalf of F. Perkins, Ltd., and by Monsieur Jean Delcroix, on behalf of F. Perkins S.A., France.

GAS TURBINE TECHNOLOGY COURSES.—Power Jets (Research and Development), Ltd., has issued the following programme of courses to be held this year at the School of Gas Turbine Technology, Farnborough Place, Farnborough, Hampshire. Aero engine design, May 17th-June 4th; Theory and Design of Compressors, June 14th-18th; Theory and Design of Turbines, June 21st-25th; Combustion and Heat Exchangers, June 28th-July 2nd; Practical Aero Engine, July 12th-23rd; Design and Applications of Industrial Gas Turbines, August 9th-27th; International Course on Aero and Industrial Gas Turbines, September 13th-October 1st; Aero Engine Design, October 11th-29th; Practical Aero Engine, November 8th-19th; Design and Applications of Industrial Gas Turbines, November 29th-December 17th.

Personal and Business

MR. G. E. CATER has been appointed general sales manager of Tecalemit, Ltd., Plymouth.

MR. J. F. WILLIS has been appointed representative in Scotland of Hopkinsons, Ltd., Huddersfield.

MR. A. J. HARWOOD has been appointed chief engineer of Auto Transmissions, Ltd., Upper York Street, Coventry.

MR. A. E. SKAN, a director of George Ellison, Ltd., Perry Barr, Birmingham, has been elected chairman of the British Plastics Federation.

ROCKWELL MACHINE TOOL COMPANY, Ltd., states that its northern office address is now 10, Canal Street, Waterloo Road, Stockport, Cheshire.

WELLWORTHY, Ltd., Lymington, announces the appointment of Mr. H. Dunn, 50, Wellington Street, Glasgow, C.2, as Scottish area sales manager.

MR. C. P. BIRKIN has been appointed editor of *Iron and Steel* in succession to the late Mr. W. E. Benbow. Mr. Birkin has been assistant editor since 1940.

DR. BERNARD G. NEAL, university lecturer in engineering at Cambridge, has been appointed Professor of Civil Engineering in the University College of Swansea.

STANLEY HOWARD, Ltd., 75, Exchange Buildings, Birmingham, has been appointed sole agent in this country for Wanderer milling and hobbing machines.

MR. A. G. PEACOCK has resigned the secretaryship of the Scientific Instrument Manufacturers' Association and has joined the board of Mervyn Instruments, St. John's, Woking, Surrey.

DR. J. W. DRINKWATER has been appointed director of engine research and development in the Ministry of Supply, in succession to Mr. R. H. Weir, who recently became principal director.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2, announces the appointment of Mr. W. H. Taylor, A.M.I.E.E., as controller of education and personnel services.

BROOK MOTORS, Ltd., announces that it has recently taken over an additional factory at Aspley, Huddersfield. It states also that the Newcastle sales office has been moved to 35, Pink Lane, Newcastle upon Tyne.

K.G.S. BEARING COMPANY, Ltd., Wolverhampton, has established a South African subsidiary entitled K.G.S. Bearing Company South Africa (Pty.), Ltd. Its address is 14, Trump Street, Selby, P.O. Box No. 10597, Johannesburg.

RUSTON AND HORNSBY, Ltd., Lincoln, announces that Mr. V. R. Prehn, works director, has been appointed assistant managing director. Mr. G. B. R. Feilden, formerly chief engineer, gas turbines, has been appointed engineering director.

LLOYD'S REGISTER OF SHIPPING states that Mr. G. R. Edgar, principal surveyor at Newcastle upon Tyne, will shortly retire, after forty years' service. He is to be succeeded at Newcastle by Mr. H. P. Urwin, principal surveyor at Sunderland.

JAMES N. CONNELL, Ltd., Union Works, Coatbridge, now operates under the title James N. Connell (Holdings), Ltd., controlling its three subsidiaries, James N. Connell, Ltd., James N. Connell Engineering, Ltd., and Coatbridge Tinplate Company, Ltd.

DEWRANCE AND CO., Ltd., states that, from April 1st, the counties of Flint, Denbigh, Caernarvon and Anglesey will be included in the area covered by the branch office at 32, Deansgate, Manchester. The remainder of Wales will continue in the area covered by the office at 6, Park Grove, Cardiff.

TOMEY INDUSTRIES, Ltd., Tyburn Road, Erdington, Birmingham, 24, has been formed to take over the businesses of Joseph Tomey and Sons, Ltd., Excelsior Gauge Company, Ltd., L. Tomey, Ltd., and J. L. Tomey, Ltd. Each of these four branches will continue to operate at its present address.

THE MINISTRY OF SUPPLY announces the following appointments:—Colonel J. D. Haigh, director of electronics research and development (defence); Mr. H. W. Forshaw, chief superintendent, Signals Research and Development Establishment, Christchurch, in succession to Dr. G. W. Sutton.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, states that its vacuum products activities have been merged with the new products department, which has been renamed the scientific apparatus department. The following appointments in that department have been announced: Mr. J. Blears, chief engineer; Mr. R. S. Clark, assistant superintendent; Mr. J. W. Buckley, sales manager; and Mr. W. J. Brown, assistant sales manager.

British Patent Specifications

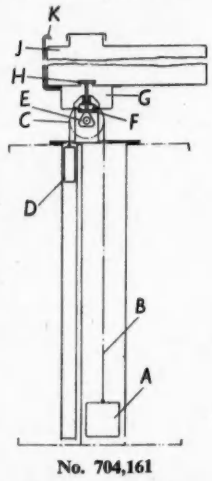
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of the specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

RAILWAY ENGINEERING

704,161. February 16, 1951.—WATER-TREATMENT PROPORTIONING DEVICE, Imperial Chemical Industries, Ltd., of Imperial Chemical House, Millbank, London, S.W.1. (*Inventors: Isaac James Rushton and Arthur John Walker.*)

The invention relates to a device for feeding treatment chemicals to water in a locomotive tender, substantially in proportion to the feed of water to the tender. As the drawing shows, the float *A* is attached to a cord *B* passing round a grooved pulley *C* to a counterweight *D*. On the spindle of the pulley is fixed a cam *E*, the projections of which serve on rotation to raise the plug *F*, which fits in a hole in the bottom of the dosage tank *G*. The plug is also attached to a second plug *H* which closes an opening between the main stock tank *J* and the dosage tank. There is an air vent for the dosage tank shown at *K*. The device is mounted on the top of the water tank of a locomotive. The float and counterweight move in upright housings of which that for the float has an inlet opening for water from the locomotive water tank. The pulley *C* is carried on a free wheel so arranged that the lowering of the float does not rotate the camshaft. The cam shown in the drawings is substantially triangular with the projections having rounded corners so that a pair of adjacent cam dwells in contact with the plug *F* secure in turn a filling of the dosage tank *G* (as in the position shown in the drawings), followed by emptying of the tank *G*, while the valve *H* is closed. These operations occur over a one-third revolution of the pulley corresponding to approximately a 6in rise in the position of the float.—*February* 17, 1954.

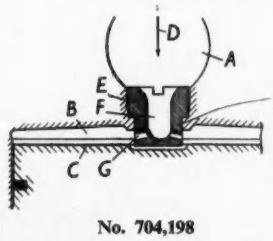


No. 704,161

INTERNAL COMBUSTION ENGINES

704,198. October 25, 1951.—DEVICE FOR INSERTION INTO THE OUTLET OF A PRECOMBUSTION CHAMBER, Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany.

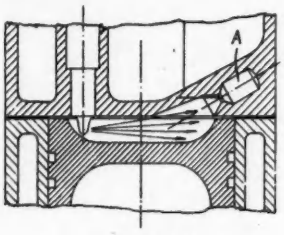
As shown in the drawing, *A* is the precombustion chamber and *B* the main combustion space above the piston *C*, which is seen in its inner dead-centre position. Fuel is injected into the chamber in the direction indicated by the arrow *D*. The substantially cup-shaped device *E* is inserted from above into a hole in the cylinder head at the base of the chamber. The base of the device projects beneath the under surface of the cylinder head and into the combustion space. The passage *F* in the device communicates with the main combustion space *B* through lateral expulsion openings *G* formed in the peripheral wall in the immediate vicinity of the base. There may be a number of these ejection openings spaced around the base. These openings may be slightly inclined downwards from the bore. The internal surface of the base or bottom end portion is well rounded and merges into the cylindrical surface of the peripheral wall *J*. Due to the rounded or hemispherical surface, the heat taken up by the base can flow without unfavourable accumulation into the peripheral wall *J* and thence to the cylinder head. This heat is then readily dissipated, particularly if the cylinder head is water cooled. Thus the thermal stressing of the insertion device does not exceed the permissible limit. The invention is applicable to diesel engines of any kind working with a precombustion chamber, but is particularly applicable to motor vehicle engines.—*February* 17, 1954.



No. 704,198

704,024.—August 17, 1951.—POSITIONING OF FUEL NOZZLES, Lanova Aktiengesellschaft, 16, Bahnhofstrasse, Zurich, Switzerland.

The invention relates to fuel-injection, internal-combustion engines with an energy cell and with a combustion chamber arranged in the piston crown, and the invention is concerned in particular with the mutual arrangement of these parts. The piston has an elongated combustion chamber in its crown. An energy cell, essentially cylindrically shaped, is arranged in the cylinder head opposite to the injection orifice of the injection nozzle. This cell is so disposed that its longitudinal axis lies in a plane through the longitudinal axis of the fuel nozzle and the centre line of the cylinder, and is inclined towards the cylinder space in such a manner that it meets the bottom of the combustion chamber substantially in its centre when the piston is in its upper dead centre position. By this arrangement it is safely ensured that an appropriate part of the fuel jet enters the energy cell through its funnel-shaped widening orifice, so that the cell discharges a powerful jet of combustion gases into the combustion chamber to produce in it an intense turbulence and promote the thorough mixture of air and fuel within the chamber. According to the invention two energy cells may be provided, each of which has a smaller capacity than the single energy cell.—*February* 17, 1954.

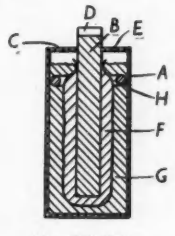


No. 704,024

ELECTRICAL ENGINEERING

703,643. April 27, 1951.—ELECTRIC PRIMARY CELLS, Magnesium Elektron, Ltd., Lumm's Lane, Clifton Junction, near Manchester. (*Inventors: Robert Geoffrey Wilkinson and William Frederick Higgins.*)

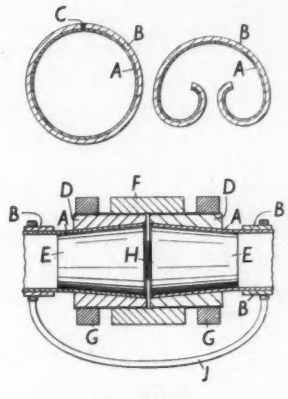
The invention relates to electric primary cells of the kind commonly known as "dry cells," having an anode usually in the form of an outer casing *A* which is consumed by the action of the electrolyte when the cell is producing current. In the accompanying drawing a casing *A* constitutes a metal anode, which is consumed during the normal use of the cell. A carbon rod *B* constitutes the cathode. The cell has a bituminous covering *C*, through which the upper end of the carbon rod projects and a brass cap *D* covers the top of the rod. The covering has an escape outlet *E* for gases. A dolly *F* containing a depolariser surrounds the lower part of the carbon rod and an electrolyte paste *G* is filled into the casing around the dolly. A rod or wire *H* constituting the sacrificial anode is bent into annular or part annular shape and is sprung into the casing so as to have a good electrical contact therewith and is disposed within the electrolyte around the upper end of the dolly. In a modification (not shown here) a small rod or plate constitutes the sacrificial anode, and a wire is connected to the anode and to the casing.—*February* 10, 1954.



No. 703,643

703,674. January 3, 1952.—OVERHEAD ELECTRIC TRANSMISSION LINES, The British Iron and Steel Research Association, 11, Park Lane, London, W.1. (*Inventor: Sir Charles Frederick Goodeve.*)

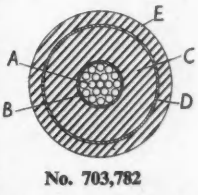
The invention relates to electric conductors used in overhead transmission lines. The two upper views of the drawing show cross sections through a tubular conductor and another form of conductor; the lower view is a longitudinal section through a joint made between two adjacent lengths of this conductor. The conductors are formed from a steel strip *A*, initially flat, which is dipped in molten aluminium, or aluminium alloy or otherwise, provided with a thin surface coating of aluminium or aluminium alloy. To one face of this strip there is bonded a strip of aluminium *B* of the same width. The composite strip is then drawn through a series of dies to form it into a hollow tube of circular cross section with the aluminium strip on the outside. The two side edges of the steel strip butt together, and the aluminium edges are secured together by a weld *C*. A conductor may comprise an inner steel tube, having an outside diameter of 1·60in and 0·05in thick and an outer aluminium tube 0·10in thick, the total outside diameter of the conductor being 1·80in. With this conductor a span of about 1200ft between towers could be obtained, using the method of calculation as put forward in the proposed new Overhead Line Regulations. The calculated sag at 22 deg. Fah. (which includes allowance for ice and snow loading) is 49ft 6in, and the calculated sag at 120 deg. Fah. is 47ft. Separately formed lengths of the hollow tubular conductor may be joined together at the ends which are attached to a common supporting tower, as shown in the lower view. The inner steel tubes *A* project beyond the ends of the outer aluminium tubes *B*. Over the ends of tubes *A* there are passed internally coned clamping sleeves *D* and conical plugs *E* are inserted in the ends of the tubes. The two clamping sleeves are formed externally with screw threads of opposite hand and are engaged and drawn together by a double tubular nut *F*, which is secured by lock nuts *G*. A compression spring *H* is inserted between the plugs to ensure firm contact between them and the steel tubes. The surfaces of the clamps and of the plugs which engage the tubes may be serrated to improve their grip on the tubes. The outer aluminium tubes *B* of the two conductors, which carry the greater part of the electrical current, are directly connected together by a loop of aluminium wire *J*, encircling and welded to the tubular conductors. A single length of conductor may, and commonly will, be supported by three or more towers.—*February* 10, 1954.



No. 703,674

703,782. August 16, 1951.—SUBMARINE CABLES, Her Majesty's Postmaster-General, the General Post Office, London, E.C.1. (*Inventor: Robert Alston Brockbank.*)

The invention relates to submarine cables, particularly cables laid in deep water. Referring to the drawing, a coaxial submarine cable to transmit signals in the frequency range of 12 kc/s to 240 kc/s consists of a multi-wire core *A* composed of nineteen wires all of the same diameter and of high tensile strength steel. They are arranged so that an inner layer of six wires surrounds a central wire and the inner layer is itself covered by an outer layer of twelve wires with an opposite lay. The outer layer has a lay of about three times that of the inner layer and lays of 6in and 2in for the outer and inner layers respectively are satisfactory. This core (overall diameter 0·26in) is surrounded by an inner conductor *B* of copper, which consists of a single tape, 0·015in thick, folded round the core with its longitudinal edges abutting. A layer *C* of suitable insulating material, such as polyethylene, is then formed over the cable to a diameter of 0·75in. An outer conductor *D* consisting of a layer of six aluminium tapes, each 0·018in thick, is then applied with a long lay. Over the outer conductor is an outer covering *E* consisting of two layers of, for example, polyvinyl chloride tape and a layer of jute with compound applied over each layer. A suitable corrosion inhibitor, such as barium chromate, is applied either to the aluminium tapes or to the outer covering. The cable was found to have a breaking load of 5½ tons and weighed about ½ ton to 1½ tons per nautical mile in water and air respectively; thus the cable has a modulus of about 11 nautical miles. In comparison, a normal single-wire armoured cable having the same attenuation coefficient would weigh about 3 tons to 4½ tons per nautical mile in water and air respectively and have a modulus of about 7 nautical miles.—*February* 10, 1954.



No. 703,782

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

CAPILLARY AND COMPRESSION FITTINGS OF COPPER AND COPPER ALLOY FOR USE WITH COPPER TUBE COMPLYING WITH B.S. 659 AND B.S. 1386.

No. 864 : 1953. Price 4s. This revised standard relates to three types of tube fittings of copper and copper alloy for use in conjunction with copper tube complying with B.S. 659, "Light-Gauge Copper Tubes for Water, Gas and Sanitation," and with B.S. 1386, "Copper Tubes to be Buried Underground." It does not attempt the complete dimensional standardisation of any of the fittings, but does, however, specify such dimensions and requirements as are essential to ensure satisfactory installation and performance.

The standard applies to the most commonly used types of fittings of nominal sizes ranging from ⅜in. to 2½in. inclusive. It includes a number of general requirements relating to design, construction and workmanship. It specifies a hydraulic test and, in the case of cast fittings, a test for porosity, and indicates the appropriate working pressures for cold water installations and hot water installations at various temperatures.

DETERMINATION OF POWER FACTOR AND PERMITTIVITY OF INSULATING MATERIALS BY THE METHOD OF HARTSHORN AND WARD

No. 2067 : 1953. Price 4s. This standard describes in detail the theory and technique of the Hartshorn and Ward method for the determination of power factor and permittivity of insulating materials at radio frequencies.

This method has been adopted as a standard test in certain British Standards for insulating materials, and it is suitable for the measurement of power factor and permittivity within a frequency range of 10 kc/s to 100 Mc/s at normal room temperatures. The method is essentially one of capacitance variation in a tuned circuit with a thermionic voltmeter as a detector of resonance. Details are given of the technique to be followed in testing moulded and sheet material, tubes and liquids, and drawings are included to illustrate the basic test circuit and some of the basic equipment involved. Appendices describe the theory of the method and detail the essential features of the main components forming the test assembly.

Launches and Trial Trips

ANITA, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for Erling H. Samuelsens Rederi A/S, Norway ; length between perpendiculars 525ft, breadth moulded 71ft, depth moulded 39ft 3in, summer draught 30ft 6in, deadweight 18,158 tons ; twenty-seven cargo oil tanks, two pump rooms, four 400 tons per hour horizontal steam pumps, two stripping pumps, steam deck machinery, two 75kW steam-driven generators, one 75kW diesel-driven generators ; Hawthorn-Doxford single-acting, two-stroke oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6600 b.h.p. at 115 r.p.m., two Scotch boilers. Trial, February 22nd.

CICERO, cargo ship ; built by Henry Robb, Ltd., for Ellerman's Wilson Line ; length between perpendiculars 290ft, breadth moulded 48ft 6in, depth moulded to upper deck 27ft., deadweight 2400 tons on 17ft 9in mean draught, service speed 13 knots ; twelve passengers ; three general cargo holds and one refrigerated hold, steam deck machinery ; triple-expansion, direct-acting, surface condensing steam engine, cylinders 20in, 34in and 54in diameter by 39in stroke, Bauer-Wach exhaust steam turbine, two cylindrical multitubular boilers supply steam at 225 lb per square inch, two 60kW and one 30kW steam-driven generators. Launch, March 5th.

HANSTELLUM, oil tanker ; built by R. and W. Hawthorn, Leslie and Co., Ltd., for Shell Tankers, Ltd.; length overall 557ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons ; thirty-three cargo oil tanks, one main pump room, four centrifugal turbine-driven cargo oil pumps, steam deck machinery, pressure ventilation system ; one set of double reduction geared compound turbines, 8250 s.h.p. maximum, steam supplied at 500 lb per square inch and 800 deg. Fah. by two Foster-Wheeler "D" pattern boilers, two 550kW geared turbine-driven alternators, one 200kW diesel-driven alternator. Launch, March 5th.

BRITISH VISION, oil tanker ; built by Joseph L. Thompson and Sons, Ltd., for the British Tanker Company, Ltd.; length between perpendiculars 515ft, breadth moulded 69ft 6in, depth moulded 37ft 6in, deadweight 16,000 tons on 30ft summer draught ; twenty-seven cargo oil tanks, two pump rooms ; N.E.M.-Doxford oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6800 b.h.p. at 119 r.p.m., service speed 13¾ knots. Launch, March 5th.

CYNUS, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for the Sociedad Transoceanica Canopus S.A.; length between perpendiculars 496ft, breadth moulded 67ft 6in, depth moulded 36ft 5in, draught 29ft. 1¼in., deadweight 16,300 tons ; trial speed 14 knots ; twenty-seven cargo oil tanks, one main pump room, three 500 tons-per-hour cargo oil pumps ; two 60kW steam-driven generators, one 25kW diesel-driven generator ; N.E.M.-Doxford, single-acting, two-stroke oil engine, five cylinders 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m., two Scotch boilers. Launch, March 6th.

TANTALLON CASTLE, cargo liner ; built by Harland and Wolff, Ltd., for the Union Castle Mail Steamship Company, Ltd.; length between perpendiculars 465ft, breadth moulded 65ft 6in, depth moulded to shelter deck 41ft 6in, 7448 gross tons ; twelve passengers ; nine watertight compartments, five main cargo holds, cargo-handling equipment includes one 80-ton, two 30-ton and eight 10-ton derricks, electric deck machinery ; three 250kW diesel-driven generators ; Harland and Wolff two-cycle, double-acting diesel engine, eight cylinders 620mm diameter by 1400mm stroke. Trial, March 6th.

EDWARD CRUSE, sludge vessel ; built by Lobnitz and Co., Ltd., for the London County Council ; length between perpendiculars 262ft, breadth moulded 43ft 6in, depth moulded 17ft 3in, mean loaded draught 12ft 6in, load displacement 3000 tons, maximum speed 11 knots; four cargo tanks to take 1560 tons of sewage sludge; two sets of triple-expansion engines taking steam at 220 lb per square inch from two Scotch boilers. Launch, March 9th.

Contracts

THE DE HAVILLAND AIRCRAFT COMPANY announces that Devlet Hava Yollari (Turkish State Air Lines) has ordered seven "Heron" Series 2 aircraft. Six will be the fifteen-passenger airline version and the remaining one an executive model. Delivery is expected to commence in the spring. The "Heron" has been designed for the shorter stage lengths and for ease in take-off and landing at small aerodromes. The aircraft has an all-up weight of 13,000 lb and is powered by four de Havilland "Gipsy Queen 30" Mk. 2 engines of 250 b.h.p. each, driving de Havilland two-bladed propellers. The Series 1 is fitted with a fixed undercarriage ; that of the Series 2 is retractable.

Catalogues

BENNETT (HYDE), Ltd., Boston Mills, Hyde, Cheshire.—Leaflet describing the uses of Gunk, D.P. solution.

THOMAS ROBINSON AND SON, Ltd., Railway Works, Rochdale.—Catalogue of modern woodworking machinery.

N. C. ASHTON, Ltd., St. Andrew's Road, Huddersfield.—Booklet describing "Narite" metal for press tools.

W. G. BAGNALL, Ltd., Castle Engine Works, Stafford.—Leaflet giving details of industrial diesel locomotives.

R. H. NEAL AND CO., Ltd., Plant House, Ealing, London, W.5, —Booklet describing the Neal travelling tower crane.

F. BODE AND SON, Ltd., Buxton Road, Leek.—Catalogue of positioning equipment for welding and assembly shops.

RUSTON AND HORNSBY, Ltd., Lincoln.—Publication 9325, narrow-gauge diesel locomotives, Marks LAT and LBT.

THE ENGLISH ELECTRIC COMPANY, Ltd., Textile Division, Stafford.—Booklet, "The Power Behind the Wool Industries," and a booklet describing small induction motors for loom drives.

ILFORD, Ltd., Ilford, London.—Booklet describing the range of Ilford X-ray films, screens and chemicals for industrial radiography.

COMMUNICATION SYSTEMS, Ltd., Strowger House, 8, Arundel Street, London, W.C.2.—Leaflet describing hotel room radio by coin box.

FISHER GOVERNOR COMPANY, Ltd., Century Works, Lewisham, London, S.E.13.—Publication D4-GB, giving details of Wizard controllers.

PETER BROTHERHOOD, Ltd., Peterborough.—Publication T.G./52, illustrating and describing self-contained turbo-generating sets.

BLAW KNOX, Ltd., 90-94, Brompton Road, London, S.W.3.—Publication BK-187, giving specification of the BK-120, Mark 11 scraper.

THE DAVID BROWN CORPORATION (SALES), Ltd., Park Works, Huddersfield.—Booklet covering the full range of David Brown helical gear units.

THE SUPERHEATER COMPANY, Ltd., 53, Haymarket, London, S.W.1.—Publication describing the "Me Le Sco" saligraph for measurement of steam purity.

STANDARD TELEPHONES AND CABLES, Ltd., Connaught House, Aldwych, London, W.C.2.—Booklet describing electronic impulse frequency telemetering.

THE BRITISH OXYGEN COMPANY, Ltd., Bridgewater House, Cleveland Row, St. James's, London, S.W.1.—Illustrated leaflet describing the Bantam cutting machine.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases, the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., March 31st.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, "Radio Astronomy," R. Hanbury Brown, 6.30 p.m.

Thurs., April 1st.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Informal Short Papers by Members, 7 p.m.——N.W. SECTION : College of Technology, Sackville Street, Manchester, 1, Technical Films, 7 p.m.——MERSEYSIDE SECTION : Electricity Service Centre, Whitechapel, Liverpool, 1, "Logic, Algebra and Relays," E. Williams, 7 p.m.

ELECTRIC RAILWAY SOCIETY

Thurs., April 1st.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, "Swiss Local Electric Railways," W. J. Wyse, 7.15 p.m.

INCORPORATED PLANT ENGINEERS

To-day, March 26th.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, Annual General Meeting, "Industrial Electrical Maintenance," D. Parkes, 7.30 p.m.

Mon., March 29th.—W. AND E. YORKS BRANCH : The University, Leeds, "High-Frequency Heat-Treatment," K. J. Irvine, 7.30 p.m.

Thurs., April 1st.—PETERBOROUGH BRANCH : Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, "The Place of the Modern Engineer in the Modern World," A. L. Berridge, 7.30 p.m.——S. WALES BRANCH : Grand Hotel, Westgate Street, Cardiff, Annual General Meeting, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., March 31st.—LONDON BRANCH : Waldorf Hotel, Aldwych, W.C.2, "Any Questions," 7.30 p.m.

INSTITUTE OF METALS

Tues., March 30th.—OXFORD LOCAL SECTION : Cadena Café, Cornmarket Street, Oxford, Annual General Meeting, followed by a Discussion, 7 p.m.

Thurs., April 1st.—LONDON LOCAL SECTION : 4, Grosvenor Gardens, S.W.1, Annual General Meeting, Discussion on "The Brittle Fracture of Metals," opening speakers L. Northcott ; "Molybdenum," A. H. Sully ; "Manganese and Chromium," and A. A. Wells, "Theoretical Aspects," 6 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., April 1st.—YORKSHIRE CENTRE : Hotel Metropole, King Street, Leeds, 1, Annual General Meeting, 7.30 p.m.——WESTERN CENTRE : Grand Hotel, Bristol, Annual General Meeting, 7.30 p.m.

Fri., April 2nd.—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, 7 p.m.

Sat., April 3rd.—MIDLANDS CENTRE : Crown Inn, Broad Street, Birmingham, Annual General Meeting, 7.30 p.m.

INSTITUTE OF WELDING

Thurs., April 1st.—N. LONDON BRANCH : The Polytechnic, Regent Street, W.1, Annual General Meeting, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, March 26th.—N.W. ASSOCIATION : Council Chambers, Chester, "The New Iron-Making and Steel-Making Plant at Shotton, Nr. Chester," J. F. R. Jones, 7.30 p.m.

Tues., March 30th.—AIRPORT MEETING : Great George Street, London, S.W.1, "Construction of a New Runway at Amman, Jordan," A. R. Macrae and A. F. Smith, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., March 29th.—LONDON STUDENTS' SECTION : Savoy Place, London, W.C.2, "The Mechanism of the Electric Spark and Some Applications," C. Grey Morgan, 6.30 p.m.

Tues., March 30th.—LONDON STUDENTS' SECTION : Drill Hall, 185, London Road, Chelmsford, "Servo Mechanisms," R. A. Middleton, 7 p.m.——N. MIDLAND CENTRE : Royal Station Hotel, York, "Design Features of Certain British Power Stations," S. D. Whetman and A. E. Powell, 7 p.m.

Thurs., April 1st.—ORDINARY MEETING : Savoy Place, London, W.C.2, "The Possibilities of a Cross-Channel Power Link," D. P. Sayers, M. E. Laborde and F. J. Lane, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 26th.—GENERAL MEETING, HYDRAULICS GROUP : Conference on Hydraulic Mechanisms, 10.30 a.m., 2.30 p.m. and 5.30 p.m.

Tues., March 30th.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, "The Future of High-Compression Petrol Engines versus Diesel Engines for Passenger Cars," 6.45 p.m.

Fri., April 2nd.—GENERAL MEETING, APPLIED MECHANICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Shrink Fit Investigations on Simple Rings and on Full-Scale Crankshaft Webs," A. S. T. Thompson, A. W. Scott and C. M. Moir, 5.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS AND INSTITUTE OF MARINE ENGINEERS—SOUTHERN JOINT BRANCH

Tues., March 30th.—Technical College, St. Mary Street, Southampton, Annual General Meeting, "The Survey of Wood Craft," J. M. Robertson, 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., March 30th.—LUTON SECTION : Small Assembly Room, Town Hall, Luton, "Uses of Liquid Air," A. H. Cockett, 7.15 p.m.

Thurs., April 1st.—READING SECTION : Great Western Hotel, Reading, "Some Wider Aspects of Management," Sir Ewart Smith, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 26th.—ORDINARY MEETING : Townsend House, Greycoat Place, London, S.W.1, "The Design and Application of Pipelines for Drainage Works," W. D. Haworth, 7 p.m.

Fri., April 2nd.—INFORMAL MEETING : Townsend House, Greycoat Place, London, S.W.1, "Some Impressions of North America," J. Foster Petree, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, March 26th.—Engineers' Club, Albert Square, Manchester, Annual General Meeting, "Engineering Aspects of Glass," R. E. Bastick and H. Cooper, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, March 26th.—Mining Institute, Newcastle upon Tyne, "Cathodic Protection of Cargo Spaces in Oil Tankers," J. Lamb, E. V. Mathias and W. Godfrey Waite, 6.15 p.m.

Mon., April 5th.—Mining Institute, Newcastle upon Tyne, "The Development of Ore Carriers in Recent Years," W. A. Stewart, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., March 30th.—SECTION LECTURE : The Library, 4, Hamilton Place, London, W.1, "Interaction between Shock Waves and Boundary Layers and its Importance in High-Speed Flight," D. W. Holder, 7 p.m.

ROYAL SOCIETY OF ARTS

To-day, March 26th.—Savoy Hotel, London, W.C.2, Banquet, Guests of Honour, T.R.H. The Duke and Duchess of Gloucester.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., March 30th.—JOINT MEETING : Manson House, Portland Place, London, W.1, "Automatic Control in the Iron and Steel Industry," S. S. Carlisle, 6.30 p.m.